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STUDY OF COMPUTER MANUAL INPUT DEVICES

TECHNICAL DOCUMENTARY REPORT NO. ESD-TDR-63-545

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FOREWORD

The guidance and assistance offered throughout the study by the contract monitor, Mr. James D. Baker, and the frequent constructive criticism offered by Dr. Walter E. Organist are gratefully acknowledged.

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ESD-TDR-63-545

STUDY OF COMPUTER MANUAL INPUT DEVICES

ABSTRACT

A study of computer manual input devices and their associated human engineering characteristics was conducted for the purpose of developing a scheme for relating these devices to operator performance characteristics, computer characteristics and system requirements. Conventional commercially available input devices such as pushbuttons, toggle switches, joysticks, etc. were surveyed. Available literature pertaining to human performance with such devices was reviewed and summarized. The suitability of devices and availability of applicable performance data are related to a generalized operator task family by a set of tables. Results of the study show a wide variety of available devices, inadequate research data establishing performance for various devices and device characteristics, and incomplete specification of operator input tasks in existing systems. Specific recommendations are made for additional research to correct these deficiencies and to guide applied research on developmental input devices such as speech recognizers. Results of an experiment studying the speed and accuracy of subjects' responses as a function of the number of response alternatives and type of response mechanism (input device) are included.

REVIEW AND APPROVAL

Publication of this technical documentary report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

For WALTER E. ORGANIST
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INTRODUCTION

With the rapid advances in engineering and scientific technologies made in the past two decades, systems for surveillance, threat evaluation, weapon control, and command control have reached a degree of complexity that makes it necessary for more and more of the system functions, traditionally assigned for human performance, to be assumed by machines.

In the majority of such cases, these changes are justifiably based on the superiority of modern machines with respect to the speed and accuracy with which functions of a quantitative nature can be performed. This trend toward function mechanization has not, however, relegated man to an insignificant or subservient role in systems operations. Rather, the mechanization trend has served to release man from routine, repetitive system tasks, making him more available for exercise of his unique intelligence capabilities in directing machine operations, and in augmenting automatic equipment in the handling of improbable events and the making of decisions involving currently non-quantifiable rules. In most instances, this executive role for humans is performed in semi-detachment from the system for which he is providing executive direction. His interaction with other system elements and the system environment is mediated by a computer which, on the one hand, processes, transduces, amplifies and disseminates the humans' actions to effect the desired system response, and on the other hand provides the human operator with data on system status and conditions of the system environment. In this concept of complementary functions of man and computer,

the critical feature affecting the individual and the combined functions of the two system elements is the adequacy of the communications link between the two. Unless the computer output devices present the system data in a form readily assimilable by the human senses, some portions of that data will either not be available for use by man or will be incorrectly received and thus constitute a source of system error. Similarly, devices provided for man informing the computer of his desires for a change in system status must be matched to the motor characteristics of the human. Mis-match must lead to loss of time by the system and to incorrect commands being received by the computer, resulting in system error. Thus, effective design of a man/computer interface to meet particular system requirements is dependent on knowledge of man's sensory and motor capabilities in using devices with various differing physical characteristics to communicate with computers whose characteristics may also vary.

The study described in the report that follows was focused on the operator input side of this man/computer communication system. Specifically, the study was initiated to perform three general tasks:

1. Conduct of a systematic survey of the human engineering characteristics of operator input devices used (or being developed for use) in communicating (on-line and off-line, with emphasis on on-line) with digital computers in information processing systems for real-time operational problems.
2. Summarize available experimental data which may be used to predict operator performance with the various combinations

of input device characteristics, digital computer characteristics, and operator task characteristics dictated by system requirements.

3. Where experimental data are not available for task 2, initiate the experimental program required to provide the needed data.

Performance of these three general tasks was intended primarily to provide a source of data for man/computer interface designers for their use in selecting a device to implement a manual input function with the selection conditioned by system requirements; i. e., operator task requirements, and device availability. The approach to performance of the study tasks was: 1) to survey existing and developmental command and control systems in order to discover the family of inputing tasks assigned to operators, with the tasks expressed in terms specific enough to permit matching with input devices; 2) to survey appropriate sources to discover the family of devices available and physically suitable for use in manual inputing; 3) to survey the literature on human performance to discover those data applicable to describing performance as a function of input task and input device; and 4) to conduct experiments on task/device combinations for which available data are lacking or inadequate.

The first three sections that follow summarize the procedure, problems and results from each of the efforts of operator task survey, input device survey, and human performance data survey. Following those sections is the summary of available data relating operator performance with the various task/device combinations, followed by a section that describes

the experimental study completed and discusses the general experimental problems in this man/computer interface area. The final sections of this main body of the report summarizes the conclusions of this study effort, and recommends directions for further work. Appendices have been attached for reporting details on available devices, references to available research reports pertinent to manual inputing and the technical details of the experimental phase of the program being reported.

SECTION 2

OPERATOR INPUT TASKS

The initial effort in this area was to review available information on existing and developmental command and control systems, specifically Air Force L-systems, in order to discover the variety of input tasks required of system operators. In describing these input tasks, two ground rules were accepted: 1) the task descriptions should be sufficiently specific, but at the same time generally stated, so that major segments of a given L-system operator's job could be described by selecting appropriate combinations of the individual inputing task descriptions and 2) the descriptions should be phrased such that selection of an input device to implement the task would not require major re-definition to reflect required input device functional characteristics. The first ground rule is an attempt to get away from over-specification of tasks, over-specification that would uniquely label a task to a particular L-system application. For example, an operator in 416-L has the task of inputing instructions to the computer to attach a label of "unknown", "hostile" or "friendly" to a track. Similarly, an operator in 473-L has the task of inputing instructions to the computer to provide symbolic, graphic or pictorial display of a particular data category. The common feature to these two specific tasks is that the operator in each case is inputing to the computer an indication of his selection of one of three alternatives. An attempt has been made to reduce all those discovered L-system input tasks to such generalized statements.

The second ground rule stated above was adopted to assure a relatively ready comparability of tasks and devices, given the functional characteristics of the devices. Again, the primary intent of the study was to provide data permitting determination of probable operator performance using a specific input device to perform a given inputing task. With that orientation, it is necessary to describe the task in terms which reflect both the system functional requirements of the task and the functional characteristics of devices available for implementing the task. As it turned out, meeting this ground rule becomes nearly automatic in describing the tasks to meet the first ground rule described above; i.e., the exercise to reduce the tasks to what is felt to be the required level of specificity results in tasks relatable to some human motor output requirement, which is in turn readily comparable to device characteristics. The systems chosen for intensive review as functionally representative of the large number of L-systems in various states of operation and development were 416-L (SAGE), 425-L (NORAD Combat Operations Center), and 473-L (Hq USAF Command and Control System). A review of data available on these systems showed that the necessary data on manual input tasks does not exist in sufficient conciseness or detail to fully meet the requirements of this study. Even with the large volume of documentation for SAGE, it is frequently necessary to infer an input task from some provided hardware capability. Similarly, the suggested design for the 473-L Integrated Console may be used to infer the variety of input tasks that an operator could perform.*

*See Tech. Note #1 to MIL-I-27114 (USAF), Human Engineering Considerations for Integrated Console Design (part of 473-L Design Specification).

Data for these systems, however, on the specific tasks that the operators are required by system design to perform have not been found. Thus, the tasks that have been isolated reflect an admixture of tasks based on relatively firm information from L-system literature, on inferences from L-system hardware characteristics and on inferences based on various bits and pieces of information on man's general role in digital computer-containing command and control systems.*

The task descriptions that have resulted are given in Table 2-1 along with specific examples of each of the generalized tasks. The order of listing of the tasks generally reflects increasing task complexity from top to bottom. Similarly, moving from top to bottom, the options associated with a task increase, reflecting a greater flexibility, or lesser predictability of a task outcome. One of the quite obvious characteristics of the man-computer communication situation provided in L-systems is the limited-choice, or, in the case of input devices, limited response options, permitted the human. It is an open question whether this pre-programmed response constraint is merely a reflection on limitations of computer technology or if this is a deliberate system design concept to constrain system operators to a specific, limited set of input-output relations.

One other comment on the tasks listed in Table 2-1 is appropriate. While the task, "Indicate selection of 1 of n alternatives" would be adequate to cover those tasks preceding it in the list, the listing of those tasks

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*See, for example, Display Problems in Aerospace Surveillance Systems AFESD-TDR-61-32, June 1961, prepared under Contract No. AF19(604)-7368, 30 October 1961, HRB-Singer, Inc.

involving the selection of 1 of 2-6 alternatives has been included as a convenience to facilitate device/task comparison discussed in Section 5.

Again, those tasks listed in Table 2-1 are representative of L-system operator input tasks. A considerably larger study in depth than that permitted by the scope of this study is required for a completely definitive role of the man-to-computer communications picture in L-systems across the board.

TABLE 2-1

MANUAL INPUT TASKS

Task	Example
Indicate selection of:	
1 of 2 alternatives -	Power on/off selection entry
1 of 3 alternatives -	Display scale selection entry
1 of 4 alternatives -	Weapon-type selection entry
1 of 5 alternatives -	Message format selection entry
1 of 6 alternatives -	DEFCON selection entry
1 of n alternatives -	Preprogrammed data processing function selection entry
Decimal digit (0-9) -	Track age entry
Decimal number (> 9) -	Track altitude (uncoded) entry
Octal digit (0-7) -	Request octal-coded file content
Octal number (> 7) -	Request octal-coded file content
Adjust magnitude -	Set sensor pointing angle
Designate location on 2-dimen. surface	Designate a specific track
Select alpha-numeric combination	Assign a track number
Compose limited-vocabulary alpha-numeric message	Data request through Query language
Compose unlimited-vocabulary alpha-numeric message	Enter intelligence summary

SECTION 3

DEVICE SURVEY

The detailed devices survey has been made in order to determine the functional and human engineering characteristics of available devices suitable for computer manual input. From the beginning it was recognized that this survey should be a sampling of the spectrum of devices rather than an exhaustive catalog of all manufacturers' products. This is a necessary and practical approach as many manufacturers offer design variations numbering in the hundreds, and some in the thousands. It was also considered necessary to limit the scope of devices to be considered to those that might reasonably be considered for use in a military command and control system. Thus, heavy-duty industrial, electrical applicance, and "economy grade" devices have been generally excluded. Further, devices were considered on the component level, excluding complete input-output consoles and special purpose combinations of devices.

The survey was initiated with general inquiry letters to companies listed under applicable device categories in purchasing indices and not already represented in Bendix Systems Division files. A review of available manufacturers' literature was then made to determine what information was lacking, and to devise a means for summarizing the pertinent data. Additional letters were then sent to most device manufacturers requesting specific data not given in their standard literature. This letter usually included a request for force-displacement details. The quality of replies ranged from excellent to no reply at all in spite of follow-up letters. While

some additional information might have been obtained through continued effort the situation seemed to have reached the point of diminishing returns. If parametric studies are ever made on specific classes of devices, some further contact with manufacturers might be worthwhile.

A total of 157 companies were contacted in the device survey. Of this number, 95 have items listed in the device survey. The remainder either did not respond or did not have a device of interest.

Device characteristics have been summarized by transferring pertinent information from each manufacturer's literature to data summary sheets. The completed summary sheets are attached as Appendix I. An attempt was made to select representative samples of each manufacturer's line on the basis of differing human engineering characteristics. Devices were selected, where possible, with sufficient electrical poles to permit binary encoding of each switch position. Variations of devices to withstand extreme environments or switches including safety locks were not considered. To illustrate the large variety of available devices, a summary of the number of devices and manufacturers listed in the survey is given in Table 3-1.

Many of the devices listed, mainly rotary switches and shaft encoders, are not complete manual input devices. They must be provided with at least a knob of some sort and usually a calibrated dial or remote indicator as well. Occasionally, more complex assemblies may be incorporated involving gears, clutches, etc. These components have not been surveyed. They, along with other details, must be considered in specific design

TABLE 3-1

SUMMARY OF INPUT DEVICE SURVEY

Device Category	No. of Items	No. of Manufacturers
Toggle Switches	62	17
Lever Switches	42	11
Slide Switches	8	5
Rocker Switches	15	6
Rotary Switches	99	26
Thumbwheel Switches	18	8
Pushbuttons, unilluminated	75	25
Pushbuttons, illuminated	147	31
Keyboards	39	18
Shaft Encoders	48	9
Joysticks	6	4

applications but they probably do not exert a primary influence on selection of the basic manual input mechanism.

Some confusion is apt to exist with regard to the classification of devices. For the most part devices have been classified according to the class names given by the manufacturers. However, areas of confusion may exist between toggles and levers, between levers and slides, and between pushbutton arrays and keyboards. Actually, confusion is more likely to exist when dealing with definitions of the classes or with the summary data than when comparing two physical devices side-by-side. Without attempting rigid, mutually exclusive definitions, a few general contrasting characteristics may be listed.

Toggle	Lever
Snap action electrical contacts	Leaf or wafer electrical contacts
Metal handle, usually bat shape	Plastic handle, variety of shapes
Distinct snap feel and audible click for maintained action	

Lever	Slide
Variable orientation between handle and mounting surface	Fixed orientation, usually 90°, between handle and mounting surface

Pushbutton Array	Keyboard
Operation by index finger usually intended	Configuration and operating force permits rapid sequential operation using several fingers.
Custom design	Fixed design available as off-the-shelf unit

Some mention should be made of types of devices not represented in the summary sheets of Appendix I. The most notable omission is a complete summary of two-dimensional controllers. This class of input device includes pantographs, joysticks, rolling balls, light guns and pencils, and voltage probe pencils with conducting glass overlays. Of these, only joysticks are known to be commercially available and then usually with an analog rather than digital output. One exception to this is a light pencil available from Digital Equipment Corporation. When other types of two-dimensional controllers are in use they are usually specially designed items. Descriptions of the design and operation of these various two-dimensional controllers may be found in the literature.

Other devices not included in the current device survey are telephone dials, and touch pushbuttons. Two companies with telephone dial devices were located, but neither replied to requests for additional information. One of the devices was a small, hand-held data recorder with telephone dial input. It could be considered an off-line input device. Touch operated pushbuttons are occasionally used in elevator control systems. In addition, two companies were heard to be developing touch pushbuttons for possible commercial sales. Again, no replies were received to requests for information. One company, Tung Sol, has recently announced a small electronic switch that can be operated by touching its input leads antennae. These leads could be connected to metal plates for a touch operated pushbutton.

All devices mentioned thus far require gross human motor action, predominantly manual, for their operation. More advanced techniques involving automatic speech recognition, eye position monitoring, neurological sensing, and hand writing readers are in various stages of development. Considerable research has been accomplished over the last few years toward development of an automatic speech recognition capability. Sufficient progress has been made that practical use could soon be made of devices capable of recognizing on the order of 15 words, the ten digits plus a few command words. Two organizations have announced development of devices with this capability, IBM Advanced Systems Development Division Lab. and Case Institute of Technology. In addition, Voice Systems, Inc. of Campbell, California, has announced that they are marketing a speech-operated

switch designed for control of light machinery and are studying possible voice-operated cash registers and mail sorting systems.

Another advanced inputing technique that might be considered in the near future for computer manual input is automatic reading of handwriting, or at least of hand printed characters. Developments in this area have also progressed to the point where practical applications can start to be considered. For example, IBM Advanced Systems Development Division has developed a device capable of reading a variety of styles of hand printed digits. Tests of this device conducted at Tufts University have produced correct readings 98.5% of the time. Also, Bell Telephone Labs have a device which recognizes whole words, from a limited vocabulary, when written in cursive script on a special conductive writing surface.

Current state-of-the-art in both speech and handwriting recognition is best obtained through a review of the literature. Research on other forms of advanced inputing techniques has not advanced to the point where their utilization can be forecast.

Two general conclusions can be drawn from the device survey; there is a wide variety of devices from which to choose and incomplete human engineering data are available for most of these devices. The main data deficiency is associated with specifications of dynamic operating characteristics; i.e., operating force and displacement. Of these, displacement data are more complete than operating force data. Quantitative data relating these two parameters are almost completely lacking; however, it is the relation between these two parameters that determines the characteristic

"feel" of a device. Manufacturers specify this relation in qualitative terms such as "snap action," positive action," "no snap action," or "light touch." The lack of quantitative data in this area suggests no popular demand and perhaps no major performance difference associated with different force/displacement relations. One notable exception is an experiment by Grisez, a summary of which has been reported by Chapanis*. This experiment shows that operating force is inversely related to several operator parameters in pushbutton operation, but that displacement as a variable has negligible effects.

Another possible reason for the lack of force/displacement characteristics is the difficulty of obtaining them. Existing instruments suitable for this task are in the family of spring testers and are generally designed to measure linear tension or compression and associated displacement. These devices are reasonably well suited to measurement of pushbutton characteristics but are not well suited to measurement of angular displacement devices such as rotary switches, toggles, rockers, and thumbwheels. Assembly of special purpose fixtures to accommodate these latter devices presents no technological problem but was beyond the scope of the present study.

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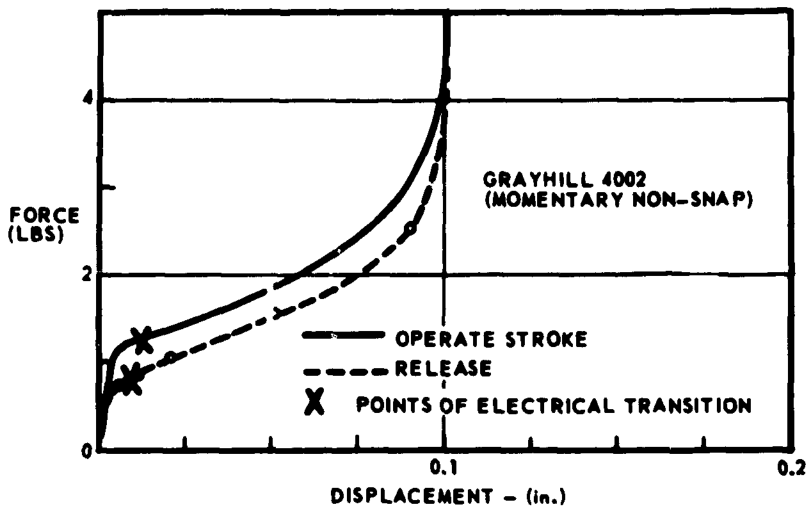
*Chapanis, A. "Engineering Psychology," Annual Review of Psychology, 14, 1963. (See p. 295 for summary of: Grisez, J. Etude comparative de boutons poussiors selon differents modes d'utilisation et en function de leurs caracteristiques de pression et de course. Bull. Centre Etudes et Recherche Psychotechniques, 8, 1959, pp. 149-156.)

Several pushbutton force/displacement characteristics were measured to illustrate the different characteristics that exist and to discover whatever practical problems might exist in obtaining these measurements. Figures 3-1 through 3-6 show sample characteristics of three types of pushbutton switch actions, momentary non-snap, momentary snap, and alternate action.

The operate stroke characteristic is produced during the inward push on the button and the release characteristic on the outward movement, when the finger is removed. The negative slope "transition" portion of some characteristics is typical of snap action switches and is associated with the over-center mechanism within the switch. These force/displacement curves shown here serve to illustrate why switches with similar operating forces and similar displacements may "feel" different. Whether or not this "feel" characteristic is an important operator performance influencing parameter is as yet an unanswered question.

These curves represent static characteristics in that the switch was stationary during the reading of each data point. Therefore the effects of kinetic friction, viscous damping, and inertia on dynamic operation are not included. Design of discrete position switches, however, indicates that these parameters would be minor in comparison to the primary effects of elastic resistance and static friction. Data points were measured with a Chatillon Model LTC-5 Tension and Compression Tester modified with a more accurate displacement scale and improved pointer. The scale used was divided into 0.01 inch steps and, with interpolation, readings at 0.005" intervals could be taken. However, maintaining comparable



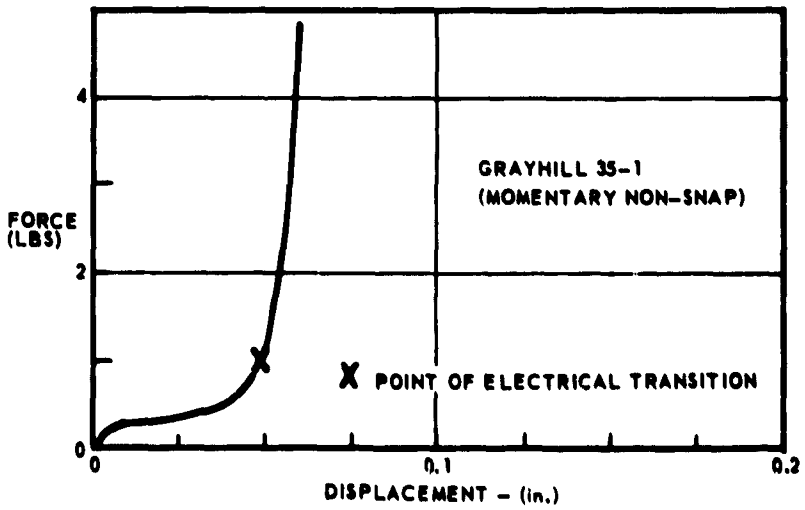


Figure 3-1 Typical Switch Force/Displacement Diagrams

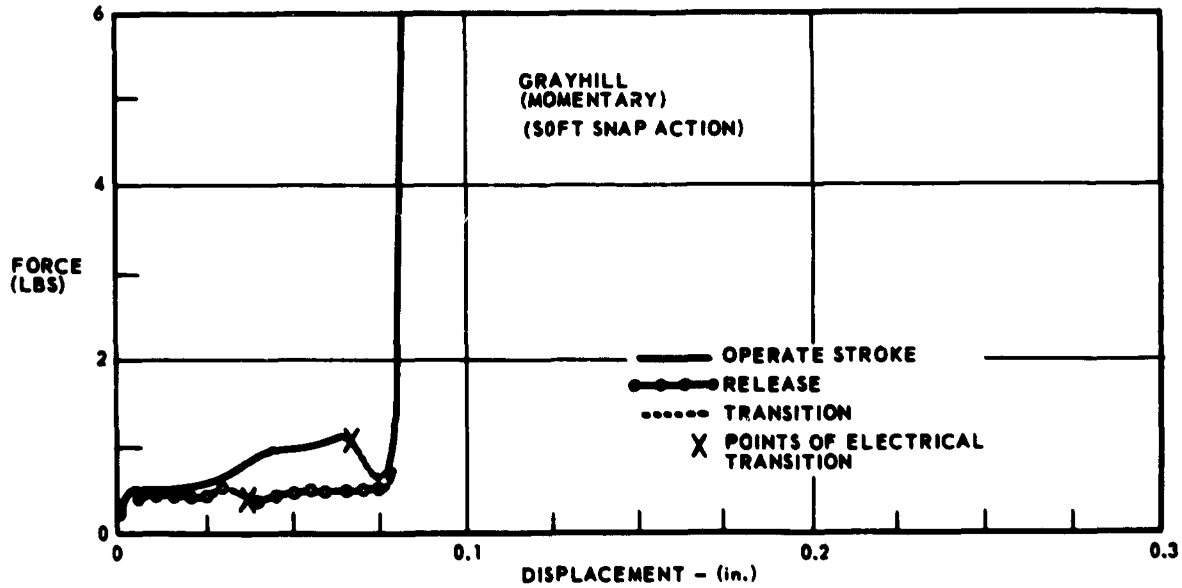


Figure 3-2 Typical Switch Force/Displacement Diagram

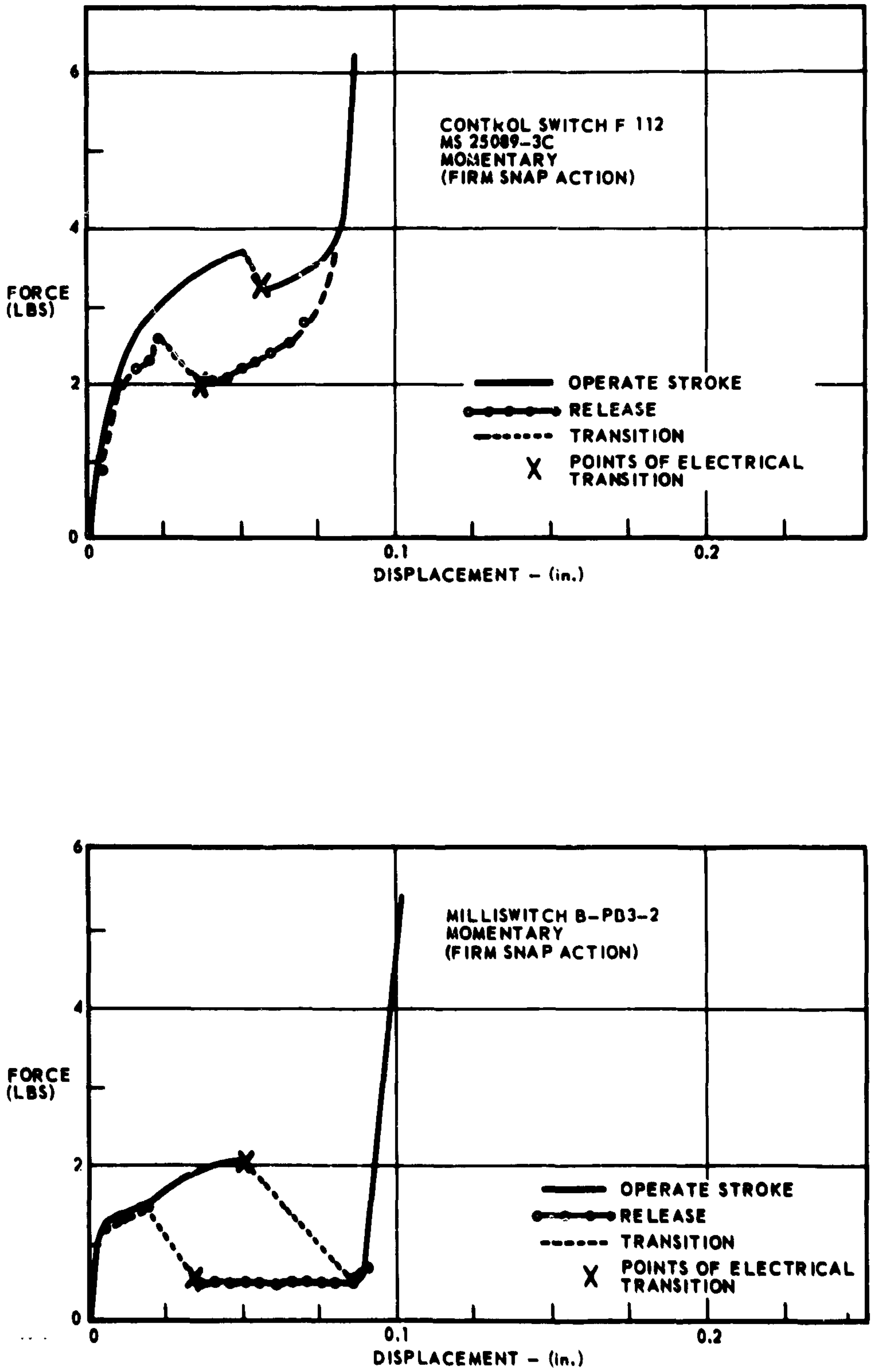
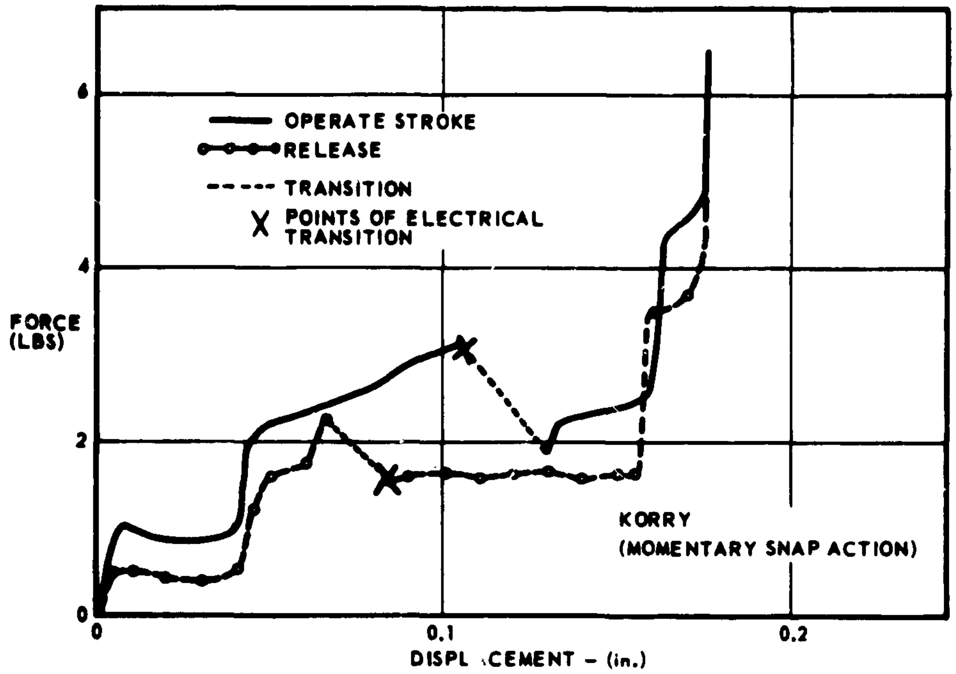


Figure 3-3 Typical Switch Force/Displacement Diagrams



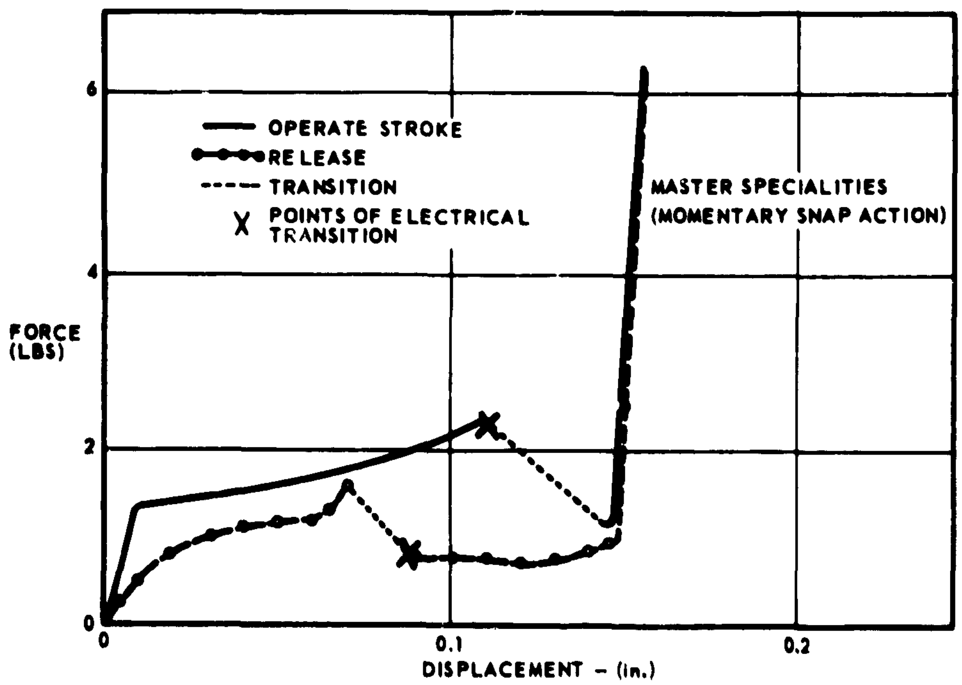
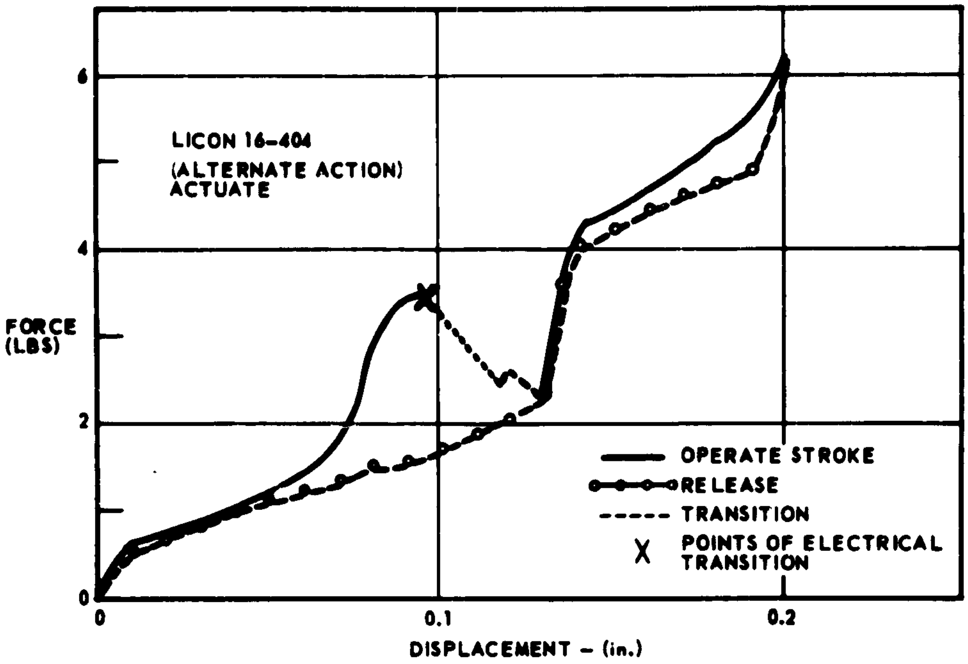


Figure 3-4 Typical Switch Force/Displacement Diagrams



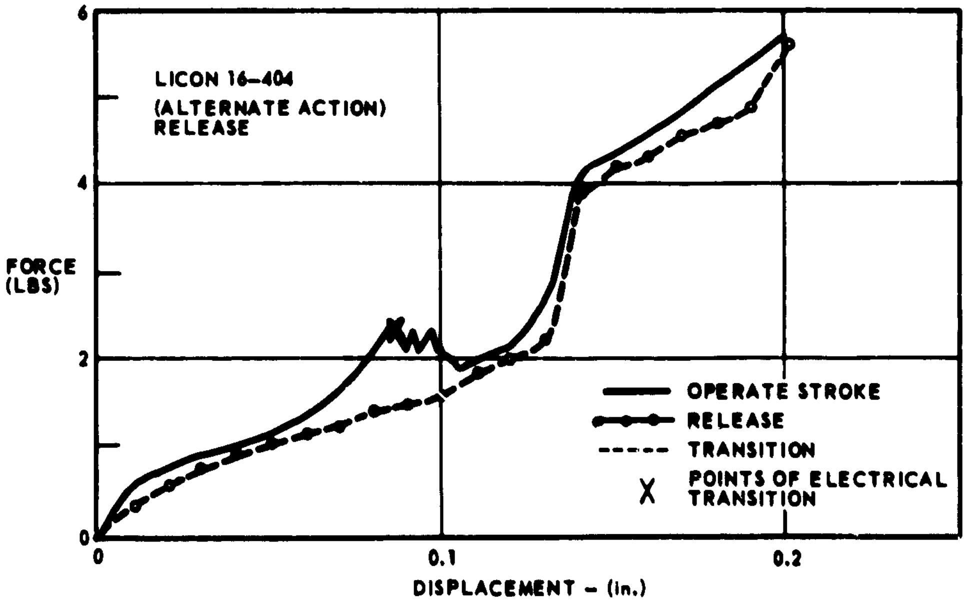
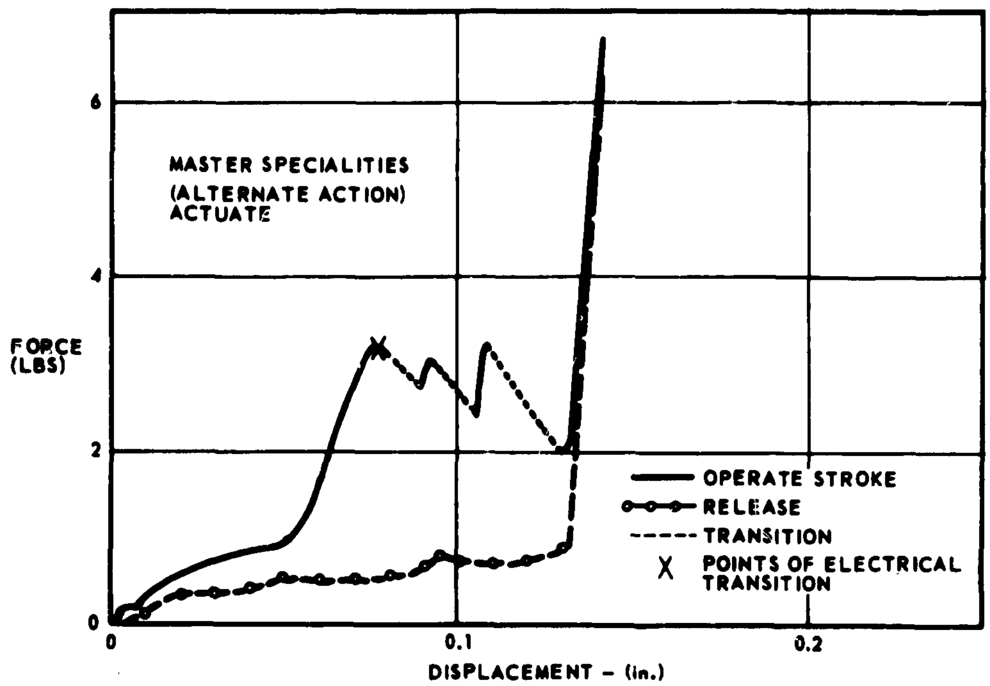


Figure 3-5 Typical Switch Force/Displacement Diagrams



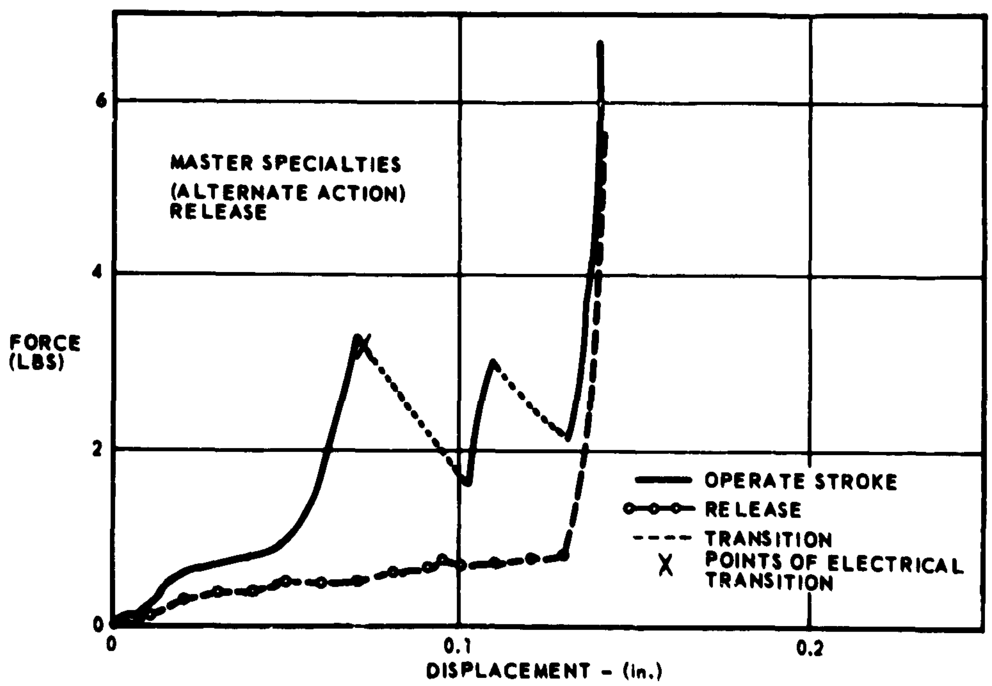


 Figure 3-6 Typical Switch Force/Displacement Diagrams

accuracy proved to be both difficult and time consuming due primarily to the lack of rigidity in the fixture. Two modifications of the present apparatus were thought of which should be considered if a more complete study is to be made of force/displacement characteristics. At a minimum the instrument should be equipped with a gear driven pointer permitting displacement measurement resolution and accuracy of about 0.002" without the need of a magnifying lens for reading the scale. An even greater convenience would result if both the displacement and force measuring elements of the fixture were equipped with electrical data pickoffs. Linear differential transformers would be well suited for this task since they would provide negligible mechanical loading. The electrical outputs could then be applied to the X and Y inputs of an oscilloscope, through necessary demodulators, to produce the characteristic curve directly on the scope face. Photographs could then be taken for permanent records thus eliminating the need for manual data plotting. In addition, switches could be activated at the normal rate of speed, thus producing true dynamic force/displacement characteristics. Also, any future study of switch force/displacement characteristics should give consideration to the difference between different samples of the same model and even differences between operation cycles of the same sample.

Another major data deficiency involves the luminance of lighted devices, notably pushbuttons. This parameter is not completely under the control of the device manufacturer, however. The lamp rating, number of lamps used, and lamp operating voltage are under the control of the user.

The manufacturer has direct control over the reflectance characteristics of the lamp housing, the lamp type to be used, and the transmission characteristics of the viewing screen. In spite of the complexity, a couple of manufacturers can provide an extensive set of luminance data for various combinations of viewing screens, number of lamps, and lamp voltage. For large screen pushbuttons, luminance distribution is also of interest. Such data are available from only one manufacturer.

SECTION 4

LITERATURE SURVEY: DEVICE/TASK PERFORMANCE DATA

A literature survey was made to compile operator performance data related to manual input tasks and devices. This literature survey began with a thorough title search and abstract screening in numerous bibliographic sources. Selected items, with abstracts where available, were entered on individual cards. Major bibliographic sources reviewed included the Tufts University Human Engineering Bibliography series, ASTIA Technical Abstract Bulletins, Psychological Abstracts, and the various specific-area bibliographies produced by technical societies, for example, the Acoustical Society of American and the Human Factors Society.

The initial search used minimum-acceptance criteria. As a result many items initially were collected which turned out to have little direct bearing on the current study. This initial listing yielded over 590 entries and required some topical classification. The first classification scheme tried was based upon the primary focus of the research being reported. This scheme was later modified to contain categories pertaining to specific devices. References are now arranged according to the type of input devices studied or used in the reported research. Thus, all available references bearing on the performance of a particular device can easily be located.

All reports reviewed and summarized present, to some extent, the results of an objective, usually empirical, investigation. References which only present "recommended" design values were not summarized

although they were screened for more basic references upon which the recommendations were presumably based. The number of references reviewed and summarized in the various topical categories is given below.

Category	No. of References Total Reviewed	Summarized
Toggle Switches	7	7
Lever Switches	2	2
Rocker Switches	1	1
Pushbuttons and Keysets	53	37
Rotary Controls	49	23
Thumbwheels	1	1
Two-Dimensional Controllers	34	10

Appendix II contains listings of all references considered together with copies of all report summaries prepared. In addition, a few references selected for review for which copies were not obtained are also included.

Report summaries have been prepared in tabular form with headings for Task, Simulus, Subjects, Response Mechanism, Conditions, and Results. Only those aspects of a research report of direct interest have been extracted and summarized. No attempt was made to prepare complete annotated bibliographies. In some cases it has been necessary to recast quantitative results to provide concise speed and accuracy data. Usually this has involved computation of means. Whenever possible the summaries state performance in terms of speed and accuracy. These two measures more precisely define operator performance than a single

combined measure such as information transmission rate and therefore have a greater range of utility. The problem, of course, is that at times the device with better speed performance does not have the best accuracy performance and a decision regarding relative importance of the two measures must be made. It is felt that this decision is better left to the person applying the performance data than to those providing it either in an original experiment or in a compilation from several sources. (See Appendix III for further discussion of combined performance measures.)

Many of the reports reviewed have not treated the response mechanism as an experimental variable. They have been concerned with such things as stimulus-response compatibility, discrimination reaction time, information transfer rate, setting cues, etc. It has been only by coincidence that these studies provide any absolute performance data for tasks and input devices (response mechanisms) of interest. This diversity of focus of attention in the various reports is accompanied also by considerable variation in such significant experimental variables as stimulus form and presentation, pacing, training, instructions, task details, and scoring procedures. Thus, it can readily be seen why the studies are not comparable for the purpose of specifying performance characteristics for task/device combinations.

SECTION 5

TASK/DEVICE/PERFORMANCE DATA COMPILATION

This section reports the initial attempt to combine the individual results of the operator input task study, the devices survey, and the human performance data survey. This attempt has taken the form of two sequential steps: 1) with the family of inputing tasks given, the descriptions of the specific devices is used to determine for each of the tasks the particular class(es) of device and the specific device(s) within the class(es) which have the functional characteristics required to implement the task, and 2) with the task/devices combinations formed, the conditions of the various experimental studies are used to indicate the pertinence of the performance data to the specific task/device combination(s).

In comparing available device applicability for implementing a particular task, three types of implementation concept have been used. First, those devices were identified that provide the required capability for implementing particular tasks when used individually. The label given to this concept of matching devices with tasks is "Physical Applicability — Individual Device". The second implementation concept involved a group of a given type of device, but with the constraint that only one of the devices in the group would be required for each unique performance of the task. This concept is called "Grouped Individuals — Discrete Operations". Finally, the third concept involves a group of a given type of device with the provision for operation of more than one device in the group for task performance. This concept is labeled "Grouped Individuals — Coded Operation".

With this coded operation, only device groups coded in a binary or decimal manner have been considered. Other coding schemes are available, of course, limited only by the ingenuity of the system designer, but the large number of such possible codes makes their consideration in the present context impractical.

One other constraint in task/device pairing has been applied. The condition has been adopted that devices will be considered functionally suitable for a task only if the full capability of the device is required. For example, a five-position toggle switch could be used to implement a task of indicating selection of one of three alternatives, but a large residual capability of the device would be untapped. Therefore, the task/device pairs of concern here are only those in which the full capability of the device is required.

Table 5-1 is a general summary of the task/device pairing. As suggested by the legend for the table, summary information is given on the physical, or functional, suitability of each of the classes of input device to meet the requirements of the various tasks. The indicated suitability is based on there being one or more specific samples of the device available and appropriate to the task under the suitability criteria given above. In addition, an indication is given in Table 5-1 of the availability of human performance data for the task/device pair. These data availability indications are quite general, and include reference to all pertinent data sources as described in Section 3 and Appendix II. Thus, the data availability indications reflect data ranging from quite marginal to directly pertinent.

TABLE 5-1

TASK DEVICE PAIRING: SUMMARY

TASKS — INDICATE SELECTION OF:	TOGGLE	LEVER	SLIDE	ROCKER	PUSHBUTTON	ROTARY	THUMBWHEEL	KEYBOARD	CURSOR CONTROL
1 OF 2 ALTERNATIVES – SUSTAINED	\ ●	\	\	\	● \	\	● \		
– TRANSIENT	\	\	\	\	● \	\			
1 OF 3 ALTERNATIVES – SUSTAINED	● \	\	\	\	X	\			
– TRANSIENT	● \	\	\	\	X	\			
1 OF 4 ALTERNATIVES – SUSTAINED	\ O	\ O	O	O	X O	● \			
– TRANSIENT	\ O	\ O	O	O	● X O	\			
1 OF 5 ALTERNATIVES – SUSTAINED	\	\			X	\			
– TRANSIENT	\	\			● X	\			
1 OF 6 ALTERNATIVES – SUSTAINED		\			X	\			
– TRANSIENT		\			X	\			
1 OF N ALTERNATIVES – SUSTAINED	O	● O	O	O	● X O	● \	● \	● \	
– TRANSIENT	O	O	O	O	● X ● O				
DECIMAL DIGIT (0–9)		●		●	● X ●	● \	● \	● \	
DECIMAL NUMBER (9)		●			X ●	● \ ● O	\ O	● \	
OCTAL DIGIT (0–7)	O	O	O	O	X ● O	\	● \	\	
OCTAL NUMBER (7)	O	O	O	O	X ● O	O	O	\	
ADJUST MAGNITUDE		●		●		● \	\		
DESIGNATE LOCATION ON 2 – DIMENSIONAL SURFACE	\ X	\ X	X	X	X				● \
SELECT ALPHA–NUMERIC COMBINATION					X ● O	O	O		
COMPOSE LIMITED–VOCABULARY ALPHA–NUMERIC MESSAGE					●			● \	
COMPOSE UNLIMITED–VOCABULARY ALPHA–NUMERIC MESSAGE								● \	

KEY:
\ – PHYSICAL APPLICABILITY – INDIVIDUAL DEVICE
X – PHYSICAL APPLICABILITY – GROUPED INDIVIDUAL, DISCRETE OPERATION
O – PHYSICAL APPLICABILITY – GROUPED INDIVIDUAL, CODED OPERATION (BINARY OR DECIMAL)
● – PERFORMANCE DATA FOUND

In Tables 5-2 through 5-10, the functional characteristics of the specific device(s) of each class of device suitable for task implementation are given. Each of the specific devices suggested is covered in the device summary sheets of Appendix I. In addition, each of the Tables contains indications of performance data availability for particular task/device pairs. Those indications are given in the form of references to specific report summary sheets in Appendix II. Note that some of the Tables contain references to reports concerning a particular task, but with no implementing devices given. This reflects a case in which the experimental use of a device failed to coincide with the device/task pairing criteria given above.

The important message of Tables 5-1 through 5-10 is two fold: 1) generally, there are several device options functionally suitable for implementing each task and 2) there are relatively few performance-data-available indications for the many task/device combinations listed. Even in those cases where several references are noted it is usually impossible to find sufficient comparable data to make a meaningful generalization.

In spite of the existence of a few pieces of appropriate data, the existence of several human engineering design standards, and the current utilization of a few highly popular types of computer input devices, this study shows a gross lack of empirical evidence supporting the superiority of any one of several devices that could be used to implement a given task.

In addition to task and stimulus characteristics, numerous detailed characteristics of the input device can conceivably influence an operator's performance with the device. Table 5-11 shows which design characteristics

are likely to have some influence on an operator's performance using the device. In addition, the table also indicates those summarized research studies which treated a particular design parameter as a variable.

Many of the design characteristics cited cannot be specified by a single numerical quantity. For example, handle or button size is a three dimensional quantity; switching action includes both descriptive and graphical quantities, and internal lighting includes hue as well as intensity. The point of this discussion is to illustrate that very little objective data exists defining the desirable human engineering characteristics of input devices and furthermore that obtaining such data is a large complex task including considerations of many parameters.

TABLE 5-2

TASK DEVICE PAIRING: TOGGLE SWITCHES

TASKS:	INDIVIDUAL		GROUPED – DISCRETE		GROUPED – CODED	
INDICATE SELECTION OF:	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES
1 OF 2 ALTERNATIVES – SUSTAINED – TRANSIENT	2 POS. MAINT. 2 POS. MOMENT. 1 SIDE	T-1, 2, 4, 6				
1 OF 3 ALTERNATIVES – SUSTAINED – TRANSIENT	3 POS MAINT. 3 POS. MOMENT. 1-2 SIDES	T-7 T-1				
1 OF 4 ALTERNATIVES – SUSTAINED – TRANSIENT	4 POS. MAINT. • 4 POS. MOMENT. 1-2 SIDES				(2) – 2 POS. MAINT. (2) – 2 POS. MOMENT.	
1 OF 5 ALTERNATIVES – SUSTAINED – TRANSIENT	5 POS. MAINT. 5 POS. MOMENT. 4 SIDES			T-5		
1 OF 6 ALTERNATIVES – SUSTAINED – TRANSIENT					(LOG_2N) – 2 POS. MAINT. (LOG_2N) – 2 POS. MOMENT.	
1 OF N ALTERNATIVES – SUSTAINED – TRANSIENT						
DECIMAL DIGIT (0–9)						
DECIMAL NUMBER (- 9)						
OCTAL DIGIT (0 – 7)					(3) – 2 POS. MAINT. OR MOMENT.	
OCTAL NUMBER (- 7)					(LOG_2N) – GROUPS OF (3) – 2 POS.	
ADJUST MAGNITUDE						
DESIGNATE LOCATION ON 2 – DIMENSIONAL SURFACE	5 POS. MAINT. OR ♦ MOMENT. 4 SIDES		(2) – 3 POS. MOMENT. 2 SIDES			
SELECT ALPHA-NUMERIC COMBINATION						
COMPOSE LIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						
COMPOSE UNLIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						

• TRIANGULAR (3-WAY) ACTION
♦ QUADRATURE (4-WAY) ACTION

TABLE 5-3

TASK DEVICE PAIRING: LEVER SWITCHES

TASKS:	INDIVIDUAL		GROUPED - DISCRETE		GROUPED - CODED	
INDICATE SELECTION OF:	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES
1 OF 2 ALTERNATIVES - SUSTAINED - TRANSIENT	2 POS. MAINT. 2 POS. MOMENT. 1 SIDE					
1 OF 3 ALTERNATIVES - SUSTAINED - TRANSIENT	3 POS. MAINT. 3 POS. MOMENT. 1-2 SIDES					
1 OF 4 ALTERNATIVES - SUSTAINED - TRANSIENT	4 POS. MAINT. 4 POS. MOMENT. 1-2 SIDES				(2) - 2 POS. MAINT. (2) - 2 POS. MOMENT.	
1 OF 5 ALTERNATIVES - SUSTAINED - TRANSIENT	5 POS. MAINT. • 5 POS. MOMENT. 1-4 SIDES					
1 OF 6 ALTERNATIVES - SUSTAINED - TRANSIENT	6 POS. MAINT. 6 POS. MOMENT. 1-2 SIDES					
1 OF N ALTERNATIVES - SUSTAINED - TRANSIENT		L-2			(LOG_2N) - 2 POS. MAINT. (LOG_2N) - 2 POS. MOMENT	
DECIMAL DIGIT (0-9)		L-2				
DECIMAL NUMBER (> 9)		L-2				L-2
OCTAL DIGIT (0 - 7)					(3) - 2 POS. MAINT. OR MOMENT	
OCTAL NUMBER (> 7)					(LOG_8) - GROUPS OF (3) - 2 POS.	
ADJUST MAGNITUDE		L-1				
DESIGNATE LOCATION ON 2 - DIMENSIONAL SURFACE	5 POS. MAINT. OR MOMENT. 4 SIDES ♦					
SELECT ALPHA-NUMERIC COMBINATION						
COMPOSE LIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						
COMPOSE UNLIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						

KEY:
- • QUADRATURE (4-WAY) OR LINEAR ACTION
- ♦ QUADRATURE ACTION

TABLE 5-4

TASK DEVICE PAIRING: SLIDE SWITCHES

TASKS:	INDIVIDUAL		GROUPED - DISCRETE		GROUPED - CODED	
INDICATE SELECTION OF:	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES
1 OF 2 ALTERNATIVES - SUSTAINED - TRANSIENT	2 POS. MAINT. 2 POS. MOMENT. 1 SIDE					
1 OF 3 ALTERNATIVES - SUSTAINED - TRANSIENT	3 POS. MAINT. 3 POS. MOMENT. 1–2 SIDES					
1 OF 4 ALTERNATIVES - SUSTAINED - TRANSIENT					(2) – 2 POS. MAINT. (2) – 2 POS. MOMENT.	
1 OF 5 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF 6 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF N ALTERNATIVES - SUSTAINED - TRANSIENT					(LOG_2N) – 2 POS. MAINT. (LOG_2N) – 2 POS. MOMENT.	
DECIMAL DIGIT (0–9)						
DECIMAL NUMBER (- 9)						
OCTAL DIGIT (0 – 7)					(3) – 2 POS. MAINT. OR MOMENT.	
OCTAL NUMBER (- 7)					(LOG_8) – GROUPS OF (3) – 2 POS.	
ADJUST MAGNITUDE						
DESIGNATE LOCATION ON 2 – DIMENSIONAL SURFACE			(2) – 3 POS. MOMENT. 2 SIDES			
SELECT ALPHA-NUMERIC COMBINATION						
COMPOSE LIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						
COMPOSE UNLIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						

TABLE 5-5

TASK DEVICE PAIRING: ROCKER SWITCHES

TASKS:	INDIVIDUAL		GROUPED – DISCRETE		GROUPED – CODED	
INDICATE SELECTION OF:	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES
1 OF 2 ALTERNATIVES – SUSTAINED – TRANSIENT	2 POS. MAINT. 2 POS. MOMENT 1 SIDE					
1 OF 3 ALTERNATIVES – SUSTAINED – TRANSIENT	3 POS. MAINT. 3 POS. MOMENT 1–2 SIDES					
1 OF 4 ALTERNATIVES – SUSTAINED – TRANSIENT					(2) – 2 POS. MAINT. (2) – 2 POS. MOMENT.	
1 OF 5 ALTERNATIVES – SUSTAINED – TRANSIENT						
1 OF 6 ALTERNATIVES – SUSTAINED – TRANSIENT						
1 OF N ALTERNATIVES – SUSTAINED – TRANSIENT					(LOG_2N) – 2 POS. MAINT. (LOG_2N) – 2 POS. MOMENT.	
DECIMAL DIGIT (0–9)		ROCKER 1				
DECIMAL NUMBER (- 9)						
OCTAL DIGIT (0 – 7)					(3) – 2 POS. MAINT. OR MOMENT.	
OCTAL NUMBER (- 7)					(LOG_8N) – GROUPS OF (3) – 2 POS.	
ADJUST MAGNITUDE		ROCKER 1				
DESIGNATE LOCATION ON 2 – DIMENSIONAL SURFACE			(2) – 3 POS. MOMENT. 2 SIDES			
SELECT ALPHA-NUMERIC COMBINATION						
COMPOSE LIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						
COMPOSE UNLIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						

TABLE 5-6

TASK DEVICE PAIRING: PUSHBUTTON SWITCHES

TASKS:	INDIVIDUAL		GROUPED – DISCRETE		GROUPED – CODED	
INDICATE SELECTION OF:	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES
1 OF 2 ALTERNATIVES – SUSTAINED – TRANSIENT	2 POS. MAINT. 2 POS. MOMENT.	PB-2 PB-2, 23, 27				
1 OF 3 ALTERNATIVES – SUSTAINED – TRANSIENT			(2) OR (3) – 2 POS. MAINT. * (2) OR (3) – 2 POS. MOMENT. *			
1 OF 4 ALTERNATIVES – SUSTAINED – TRANSIENT			(3) OR (4) – 2 POS. MAINT. * (3) OR (4) – 2 POS. MOMENT. *	PB-27	(2) – 2 POS. MAINT. (2) – 2 POS. MOMENT.	
1 OF 5 ALTERNATIVES – SUSTAINED – TRANSIENT			(4) OR (5) – 2 MAINT. (4) OR (5) – 2 POS. MAINT. *	PB-3		
1 OF 6 ALTERNATIVES – SUSTAINED – TRANSIENT			(5) OR (6) – 2 POS. MAINT. * (5) OR (6) – 2 POS. MOMENT. *			
1 OF N ALTERNATIVES – SUSTAINED – TRANSIENT			(N–1) OR (N) – 2 POS. MAINT. * (N–1) OR (N) – 2 POS. MOMENT. *	PB-22, 24 PB-9, 20, 26, 27	(LOG_3N) – 2 POS. MAINT. (LOG_2N) – 2 POS. MOMENT.	PB-24, 29 PB-6 7, 8, 14, 28
DECIMAL DIGIT (0–9)			(9) OR (10) – 2 POS. MAINT. * OR MOMENT. *	PB-17, 26, 28 30, 31		PB-24, 29
DECIMAL NUMBER (> 9)			(N–1) OR (N) – 2 POS. MAINT. OR MOMENT. *	PB-28, 30, 31		
OCTAL DIGIT (0 – 7)			(7) OR (8) – 2 POS. MAINT. OR MOMENT. *	PB-28	(3) – 2 POS. MAINT. OR MOMENT	
OCTAL NUMBER (> 7)			(N–1) OR (N) – 2 POS. MAINT. OR MOMENT. *	PB-28	(LOG_8N) – GROUPS OF (3) – 2 POS.	PB-28
ADJUST MAGNITUDE						
DESIGNATE LOCATION ON 2 – DIMENSIONAL SURFACE			(MATRIX) – 2 POS. MAINT. OR MOMENT. * OR (4) – 2 POS. PAIRS INTERLOCK			
SELECT ALPHA-NUMERIC COMBINATION			(260) – 2 POS. *		(26) – 2 POS. INTERLOCKED PLUS (1 – 2 POS. INTERLOCKED	PB-10
COMPOSE LIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						PB-29
COMPOSE UNLIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						

* INTERLOCKED

TABLE 5-7

TASK DEVICE PAIRING: ROTARY SWITCHES

TASKS:	INDIVIDUAL		GROUPED - DISCRETE		GROUPED - CODED	
INDICATE SELECTION OF:	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES
1 OF 2 ALTERNATIVES - SUSTAINED - TRANSIENT	2 POS. MAINT. 2 POS. MOMENT. 1 SIDE					
1 OF 3 ALTERNATIVES - SUSTAINED - TRANSIENT	3 POS. MAINT. 3 POS. MOMENT. 1-2 SIDES					
1 OF 4 ALTERNATIVES - SUSTAINED - TRANSIENT	4 POS. MAINT. 4 POS. MOMENT. 1 SIDE	R-6				
1 OF 5 ALTERNATIVES - SUSTAINED - TRANSIENT	5 POS. MAINT. 5 POS. MOMENT. 1 SIDE					
1 OF 6 ALTERNATIVES - SUSTAINED - TRANSIENT	6 POS. MAINT. 6 POS. MOMENT. 1 SIDE					
1 OF N ALTERNATIVES - SUSTAINED - TRANSIENT	N POS. (N < 1000 APPROX.)	R-3, 7, 10, 23				
DECIMAL DIGIT (0-9)	10 POS.	R-10, 23				
DECIMAL NUMBER (> 9)	< 1000 POS.	R-9			$(LOG_{10}N)$ - 10 POS.	R-23
OCTAL DIGIT (0 - 7)	8 POS.					
OCTAL NUMBER (> 7)	< 48 POS.				(LOG_8N) - 8 POS.	
ADJUST MAGNITUDE	CONTINUOUS ADJUSTMENT	R-1, 2, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25				
DESIGNATE LOCATION ON 2 - DIMENSIONAL SURFACE						
SELECT ALPHA-NUMERIC COMBINATION					(1) - 26 POS. PLUS (1) - 10 POS.	
COMPOSE LIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						
COMPOSE UNLIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						

TABLE 5-8

TASK DEVICE PAIRING: THUMBWHEEL

TASKS:	INDIVIDUAL		GROUPED - DISCRETE		GROUPED - CODED	
INDICATE SELECTION OF:	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES
1 OF 2 ALTERNATIVES - SUSTAINED - TRANSIENT	2 POS. MAINT.	TH-1				
1 OF 3 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF 4 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF 5 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF 6 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF N ALTERNATIVES - SUSTAINED - TRANSIENT	N POS. 25 APPROX.)	TH-1				
DECIMAL DIGIT (0-9)	10 POS	TH-1				
DECIMAL NUMBER (9)	25 APPROX				$(LOG_{10}N)$ - 10 POS.	
OCTAL DIGIT (0 - 7)	8 POS.	TH-1				
OCTAL NUMBER (7)	25 APPROX.				(LOG_8N) - 8 POS.	
ADJUST MAGNITUDE	CONTINUOUS ADJUSTMENT					
DESIGNATE LOCATION ON 2 - DIMENSIONAL SURFACE						
SELECT ALPHA-NUMERIC COMBINATION					(1) - 26 POS. PLUS (1) - 10 POS.	
COMPOSE LIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						
COMPOSE UNLIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE						

TABLE 5-9

TASK DEVICE PAIRING: KEYBOARDS

TASKS:	INDIVIDUAL		GROUPED - DISCRETE		GROUPED - CODED	
INDICATE SELECTION OF:	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES
1 OF 2 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF 3 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF 4 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF 5 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF 6 ALTERNATIVES - SUSTAINED - TRANSIENT						
1 OF N ALTERNATIVES - SUSTAINED - TRANSIENT	N KEY	PB-7, 8, 24				
DECIMAL DIGIT (0-9)	10 KEY NUMERIC	PB-17, 24, 30, 31				
DECIMAL NUMBER (- 9)	10 KEY NUMERIC	PB-11, 12, 13, 24, 30, 31				
OCTAL DIGIT (0 - 7)	10 KEY NUMERIC					
OCTAL NUMBER (- 7)	10 KEY NUMERIC					
ADJUST MAGNITUDE	10 KEY NUMERIC					
DESIGNATE LOCATION ON 2 - DIMENSIONAL SURFACE						
SELECT ALPHA-NUMERIC COMBINATION						
COMPOSE LIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE	ALPHA-NUMERIC KEY BOARD	K-3				
COMPOSE UNLIMITED-VOCABULARY ALPHA-NUMERIC MESSAGE	ALPHA-NUMERIC KEY BOARD	K-1, 2, 3				

TABLE 5-10

TASK DEVICE PAIRING: 2-DIMENSIONAL CONTROLS

TASKS:	INDIVIDUAL		GROUPED – DISCRETE		GROUPED – CODED	
INDICATE SELECTION OF:	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES	DEVICE TYPE	REFERENCES
1 OF 2 ALTERNATIVES – SUSTAINED – TRANSIENT						
1 OF 3 ALTERNATIVES – SUSTAINED – TRANSIENT						
1 OF 4 ALTERNATIVES – SUSTAINED – TRANSIENT						
1 OF 5 ALTERNATIVES – SUSTAINED – TRANSIENT						
1 OF 6 ALTERNATIVES – SUSTAINED – TRANSIENT						
1 OF N ALTERNATIVES – SUSTAINED – TRANSIENT						
DECIMAL DIGIT (0–9)						
DECIMAL NUMBER (- 9)						
OCTAL DIGIT (0 – 7)						
OCTAL NUMBER (- 7)						
ADJUST MAGNITUDE						
DESIGNATE LOCATION ON 2 – DIMENSIONAL SURFACE	JOYSTICK, ROLLING BALL, VOLTAGE PROBE, LIGHT GUN AND PENCIL, PANTOGRAPH	C–1 THRU 10				
SELECT ALPHA–NUMERIC COMBINATION						
COMPOSE LIMITED–VOCABULARY ALPHA–NUMERIC MESSAGE						
COMPOSE UNLIMITED–VOCABULARY ALPHA–NUMERIC MESSAGE						

TABLE 5-11

INPUT DEVICE DESIGN CHARACTERISTICS

	Toggle	Lever	Slide	Rocker	Rotary Selector	Thumbwheel Selector	Pushbutton	Keyboard	Rotary Control	Joystick	Rolling Ball	Pencil or gun
Number of positions									NA	NA	NA	NA
Displacement	2						11				4	NA
Handle or butter size and shape	2, 5				10		2, 10, 11		5, 6, 7, 12, 14, 16, 17, 22	1, 8		
Handle or butter finish												
Operating force	2, 6				10		11		5, 6, 8, 16, 18	1		
Switching action							11		NA	NA	NA	NA
Resolution	NA	NA	NA	NA	NA	NA	NA	NA	2			
Inertia	NA	NA	NA	NA	NA	NA	NA	NA	5			
Internal lighting	NA		NA						NA	NA	NA	NA
Direction to increase	NA	NA	NA	NA	1	1	NA	NA	1			
Control/display ratio	NA	NA	NA	NA	NA	NA	NA	NA	7, 8, 24	1, 6, 7, 8	4, 7	NA
Matrix size and configuration	7						2, 11, 20 24, 28, 29	K6	14, 15	NA	NA	NA
Orientation on panel	1, 2								5, 6, 22			NA
Spacing between items	2, 7						2, 10		14, 15	NA	NA	NA
Panel plane and slope	1						12					NA
Location on panel	4	1					5, 23		2, 5, 6, 13, 15, 23			
Labeling										NA	NA	NA
Dial type	NA	NA	NA	NA			NA	NA	9	NA	NA	NA
Stimulus form							18					
Set cues	3											

SECTION 6

EXPERIMENTAL RESULTS

The previous section has shown a need for a large amount of additional experimental data before anything like a designer's handbook can be assembled to aid in the selection of a particular device for a given manual input task. The scope of this contract permitted a modest experimental effort originally intended to test any hypothesis that might be developed. In view of the meager information in existence, it was found impossible to draw any conclusion regarding the superiority of one device over another. Thus it was decided that better use could be made of the experimental effort if it was devoted to collection of performance data for several devices on some typical task. The task chosen was the selection of one of several sets of alternatives specifically 1 of 2, 4, 7 or 10 alternatives. Devices studied were representative samples of the four basic types of devices that could reasonably be used in a grouped-discrete manner to implement random selection of one of a set of choices, namely toggle, slide rocker, and pushbutton switches. Neither rotary selector switches nor thumbwheels were included because each is inherently designed for an ordered sequence setting task. Random selection in a practical context would typically require the actuation of an additional READ control after completion of the selection, thus making either of these devices obviously inferior insofar as speed of performance is concerned. More complicated device configurations such as a symbolic scope display of alternatives with cursor selection or grouped-coded configurations were not studied due to limitations

in the scope of the effort that could be undertaken. The mode of stimulus presentation was intentionally selected to provide less than optimum stimulus-response compatibility in order to produce absolute performance results closer to those that might be expected in a real situation. Spacial stimulus coding with the indicator adjacent to each corresponding switch would be the most compatible and probably provide the best performance. Practical systems, however, rarely have an operator behave as a simple automaton in a choice selection task. On the other hand, the focus of attention for this experiment was to be the type of response mechanism and number of alternatives and not elements of decision making. Therefore, a somewhat middle of the road choice was made and symbolic stimulus coding was used. It was further decided that the set of symbols used should be familiar to the subject and from an ordered sequence, i. e., the alphabet. A detailed description of this experiment and results obtained are contained in Appendix III. In summary, the experiment showed statistically significant difference due to devices, alternatives, and subjects. None of the interactions was significant. The results of this experiment were used as a vehicle to explore the effect of several methods of combining speed and accuracy data into a single performance score. The results of this effort are also contained in Appendix III.

The experiment conducted under this contract effort is but one of many which could and should be conducted to provide data for more objective selection of computer input devices in military systems.

SECTION 7

DEVELOPMENTAL DEVICES

While the study effort was focused primarily on conventional commercially available devices, a few developmental devices and proposed techniques deserve some discussion.

Three references (see Appendix II, reference summaries Keyboard 4, 5, and 6) pertaining to improved typewriter keyboards were located and reviewed. Two of these present a convincing argument for improved speed performance if the keyboard is rearranged to minimize the sequential use of the same finger and hand. At least three different keyboard designs have been proposed. All are based upon statistical information regarding the frequency of occurrence of letters and letter pairs in the language. The third reference in this group reported the results of an extensive comparative study of one of these revised keyboards, the Dvorak-Dealey, and the standard keyboard. Results showed no important difference between the two keyboards after several months of practice. From this it is concluded that any advantages of the "rythmic" keyboards are likely to be of marginal practical significance and that further research along this line would have low potential payoff for military systems.

There is some evidence that greatly improved speed performance could be obtained in entering limited and unlimited vocabulary messages via multiple-press keyboards. Multiple-press keyboards are devices which require the simultaneous pressing of two or more keys. The only known commercially available device of this type is the Stenotype machine used

by stenographers for machine shorthand. In typical use, these are general purpose machines in that they can be used to record unrestricted messages, including punctuation, in a quasi-phonetic code. No experiments studying the speed and accuracy of Stenotype machines were found but manufacturers' literature indicates that after training operators are capable of writing 150 or more words a minute.

Multiple press keyboards which have been studied experimentally have used from 4 to 10 keys with each key assigned to a particular finger of a particular hand. The keys have usually been conveniently located under the assigned finger with the hand held in a natural position. Several references pertaining to this type of keyboard were located and summarized. Some of these (Appendix II, PB 5-8, 14, and 25) were concerned with discrimination reaction time and used a spatial stimulus. Others (Appendix II, PB 28 and 29) studied the use of a four key keyboard for numerical data entry in binary code. In one study of direct practical significance (Appendix II PB 16) three subjects typed whole words, with a single press pattern, from a vocabulary of 100 words at an average rate of 42 wpm. While the rate obtained after modest practice was not superior to conventional typing performance it was comparable. Whether or not additional practice would result in significant improvement is an open question. A discrimination reaction study (spatial stimulus) (Appendix II, PB 14) using 10 keys and 1031 alternatives achieved rates of about 150 patterns per minute.

Other examples of practical use of multiple-press keyboards for data entry are the U. S. and Canadian mail sorting systems. Although occasional

mention of these systems was noted during the study, no specific report references were found.

Even if multiple press keyboards would not yield significantly greater speed, they still may be desirable as computer input devices since they would permit simpler computer programs for input processing. Also, less memory would be required to store whole-word codes than to store a series of alphabetic code groups.

The information acquired during this study suggests that multiple-press keyboards should receive greater attention as computer manual input devices. In particular, increased operator input speed and simplicity of input processing programs would appear to result if multiple press keyboards were used in place of conventional typewriters for limited vocabulary message entry tasks. These advantages would be gained at the expense, however, of increased operator training and the inability of untrained operators to operate the device in an emergency.

Additional research is required to establish probable training times and typical speed and accuracy data for trained and untrained operators for a variety of input tasks. Also, both the Stenotype keyboard and one key per finger configuration should be studied. It would be of interest to learn why considerably faster performance is achieved on the seemingly more difficult Stenotype keyboard than on the 8 or 10 key hand configured keyboards.

An input technique which has been suggested but not studied is the use of a two-dimensional controller and a CRT display for alternative se-

lection. The alternatives would be displayed on the CRT in word or symbolic form. The operator would designate his selection by "tagging" the selected alternative with his controller, joystick, light pencil, or etc. Whether or not this input technique would result in improved operator performance over switch matrices or keyboards is a question to be settled by experimentation. For situations in which an operator must contend with a large set of alternatives but only a limited subset at any one time, this proposed technique should permit a reduction in control panel area over the switch matrix, and reduced training time over the keyboard.

On the surface it would seem that speech would be an ideal method of computer manual input. Numerous authors have advocated this point of view. However, one study (See Appendix II, PB 13) suggests that speech input may be neither better nor desirable than key punching. This study found that inexperienced keypunchers could read digits about twice as fast as they could key punch them but if given a choice they preferred keying to reading. Also, it was found that an experienced keypunch operator could key digits just as fast as she could read them. While this study should be only considered preliminary since it dealt with a single task, used a small number of subjects, and did not use an actual speech recognition device (or attempt to simulate constraints associated with such devices), it does indicate that further research is required to determine those circumstances under which speech may be the better input mode. The state-of-the-art in speech recognition devices indicates that such research should be undertaken immediately before enthusiasm for this new and novel input technique leads to its improper incorporation into some system.

Insofar as handwriting or handprinting input is concerned, this technique would appear to offer no improvement in performance over keypunching or speech. It may require less training, however, than keypunching, especially if the writing can be only moderately constrained.

SECTION 8

CONCLUSIONS

Surveys to compile data on the variety of manual input devices available, the input tasks assigned humans in L-systems, and the human performance data relating devices and tasks have produced the following results:

There is an extremely wide variety of conventional devices available, and suitable for application in manual computer inputing. This variety of devices is composed primarily of switches of various types (e.g., toggle, lever, slide, rocker rotary, thumbwheel, and pushbutton) and functional capability, i.e., number of circuits controlled. Some 466 representative devices of these types have been identified and their physical characteristics summarized. In addition, more complicated devices such as keyboards, shaft encoders and two-dimensional controllers have been isolated. These number 93, and have been partially summarized. A major deficiency in these device summaries is with respect to the dynamic operating characteristics of the devices, characteristics such as force-displacement which may be expected to influence the relative operation of the various devices. Such data are not available from device manufacturers or other sources.

A survey has been made of the computer input tasks assigned or proposed for L-system operators with available literature as the data source. From these raw data, a family of specific operator input tasks has been formed. Due to the surprising lack of data on the specific roles

of humans in inputing functions, the family of tasks formed, while certainly representative, cannot be defended as complete and definitive.

The many sources of data on psychophysical and motor behavior have been surveyed to collect available data on human performance with computer input devices in performing the types of task identified with manual computer inputing. The pertinent characteristics of such reported research have been summarized. The survey shows that, despite the long-standing availability and liberal application of identified devices and the similar relationship of the tasks identified, reported research is quite inadequate in quantity and quality for even an approximation to description of human performance as a function of input device and task.

In general summary of the survey effort, an extremely large number of potentially applicable devices have been identified, but the great majority of devices do not have the associated data on operating characteristics required for human engineering evaluation (assuming that human engineering data were available). While a representative set of operator input tasks has been isolated, available sources of data have been inadequate for assuring completeness of the task family so far evolved. Finally, the survey of human performance literature has produced a disappointing inadequate data base for relating devices and tasks through performance data.

SECTION 9

RECOMMENDATIONS

As is generally true in exploratory, survey efforts of the type reported here, more problem areas and questions than solutions and answers are produced. Several problem areas are identified below, since it is felt that these areas are particularly pertinent to requirements for applied research in the general area of man-computer communications, specifically in command and control system applications.

These applied research requirements may be categorized in three areas. The first area concerns man's role in systems containing major digital computer facilities; the second, with experimental efforts required to provide human engineering data on existing input devices; and the third, with survey and evaluation of potential devices now in developmental stages.

Considering the major efforts involved in the development of command and control systems of one level of complexity or another and the frequently announced importance of man's role in such systems, it is quite surprising how little definitive, systematic attention has been devoted to (or, at least, reported on) man's role in such systems. Such definitions of human functions in command and control systems are required not only to permit specification of the interface hardware (in the context of this study, input devices) required, but also to permit discovery of those areas of hardware technology for which state-of-the-art advancement is required in order to more fully exploit human capabilities. Therefore, it is recommended that concerted effort be devoted to specifying the manual input requirements of

existing and developmental L-systems in order to derive an adequate family of manual input tasks.

With respect to human engineering guidance in the matching of tasks and devices, the summary in Section 5 above shows the inadequacy of the existing data based on human performance. While an extremely large experimental program would be required to adequately fill each cell of the task/device matrix in Section 5, selective experiments are required to provide performance data for some of the more prominent task/device pairs. Consider, for example, the rather prominent task on alternative selection in man-computer communications. The literature survey reported above revealed little in the way of data that could be used in evaluating the relative utility of matrices of the various available switches, and much less that would permit cross comparison of discrete versus coded (multiple press) switch operation. Therefore, it is recommended that experimentation be initiated on the task/device pairs listed below as an initial approach to providing the human performance data required for rational input task implementing decisions.

Task	Devices to be Evaluated
Choice Selection (1 of n alternatives)	Discrete switch matrix (several switch types) Coded pushbutton "Keyset" (multiple press)
Numeric Data Entry (decimal number)	Numeric Keyboard (adding machine type) Conventional typewriter keyboard Binary Coded pushbutton "Keyset" (multiple press)
Adjust Magnitude	Rotary Selector switches Thumbwheel switches Slewed counter

Task	Devices to be Evaluated
Message Input (limited vocabulary alpha-numeric message)	Conventional typewriter keyboard Coded keyboard (multiple press)

In addition the devices survey portion of this study showed that very little data exist relating device operating characteristics, e.g., force/displacement, actuation direction, size, etc., to operator performance. Such data are required for a thorough understanding of human performance with the various available devices, and for providing guidance to current and future device development work.

The third area of applied research requirements concerns current hardware developments which hold promise for application to manual input As briefly reviewed in Section 6, development is progressing rapidly in the areas of mechanical recognition of speech and handwriting, and considerable attention is being given to direct sensing of the neurological concommitants of human motor behavior. While the application of such developments to permit more "natural" behavior of computer operators is intuitively attractive, evaluation is required to determine what if any gains may be realized in manual input tasks. Therefore, it is recommended that a two-phase effort be initiated to effect such an evaluation. Since these developments are currently relatively uncoordinated, the first task should be that of summarizing current capabilities and limitations of advanced techniques and of forecasting future capabilities. The second task required is that of empirical evaluation of manual input performance with these potential techniques. Since the techniques are developmental, experimentation will probably have to be done with set-ups which simulate functional characteristics of these potentially useful devices and techniques

APPENDIX I

DEVICE SURVEY DATA SUMMARY

The tabulation of manual input device characteristics pertinent to this study is contained in the accompanying forms. This tabulation of what we consider human engineering characteristics of the various devices is arranged in columns of decreasing level of importance, (from left to right on the summary sheets.) Information contained in the forms, is from left to right, of the following types: device reference, functional capability, dynamic characteristics, statis characteristics, overall size, price, and remarks. Exact column headings vary somewhat with the specific class of device and are self-explanatory. Overall size was included since these dimensions determine how close devices can be spaced when used in a group. Price, although not a direct consideration in the context, was included to aid in the possible procurement of devices of experimentation.

These forms do not represent all models available from the various manufacturers but only those devices judged to be significantly different on the basis of operating characteristics or appearance. In some cases, options are noted within a single entry in the appropriate column or in remarks. Blank spaces indicate data available from the manufacturer at the time of preparations.

Data contained in these forms should not be used for final part selection or detailed design purposes. Rather current manufacturers' literature and price sheets should be used.

(A listing herein does not constitute endorsement of the device in any manner by Bendix Systems Division or by United States Air Force.)

TOGGLE SWITCHES

SHEET 1 OF 3

TRADE NAME	MFG CODE	MODEL NUMBER	NO. POS.	DISPLACEMENT	OPERATING FORCE	SWITCHING ACTION	HANDLE: STYLE	HANDLE: FINISH	HANDLE: END DIA (IN.)	HANDLE: LENGTH (IN.)	BEHIND PANEL DIMENSIONS: WIDTH (IN.)	BEHIND PANEL DIMENSIONS: LENGTH (IN.)	BEHIND PANEL DIMENSIONS: DEPTH (IN.)	ELECTRICAL CONFIGURATION	PRICE	REMARKS OR SPECIAL FEATURES
	Alco	MST-205P	3	15°		Maint.	Bat	Chrome	0.094	0.41	0.45	0.69	-4.0	DPDT 5A @ 115 VAC	$2.5[illegible]	SPST and other actions avail.
		MST-205D	2	36°		Mom.	Bat	Chrome	0.094	0.41	0.4[illegible]	0.69	-4.0	DPDT 5A @ 115 VAC	$2.[illegible]	
		MST-215N	2	30 x 4°		Maint.	Straight Round	Chrome	110	[illegible]	0.[illegible]	0.69	-4.0	DPDT 5A @ 115 VAC	$2.1[illegible]	Removable covered [illegible] avail. for handle
	A[illegible]	TS-4	2			Maint.	Round Knob			21/64	0.50	0.50	-4.0	DPDT 5A @ 115 VAC	$1.90	SPST other actions and [illegible] handles avail.
		TM-4	2			Mom.	Round Knob			21/64	0.50	0.50	-4.0	DPDT 5A @ 115 VAC		
		TK-4	3			1 Side Mom. 1 Side Maint.	Round Knob			21/64	0.50	0.50	-4.0	DPDT 5A @ 115 VAC		
	A-H & H	[illegible]	2	[illegible]		Maint.	Bat	Satin Chrome		21/32	41/64	1 1/32	-1 1/4	DPDT 5A @ 125V		Other Elect. Config. Avail. MIL-S-[illegible] Various [illegible] Toggles
	[illegible]	[illegible]		20	20 [illegible]	Mom.	Trigger Bar	Bright Nickel	[illegible] Flat	21/32	1/2	1 1/8	-1 1/4	DPDT [illegible] @ 125V		[illegible] handle and other actions avail.
	[illegible]	A[illegible] K[illegible]	2	46 [illegible]		Maint.	Bat	Passivated Stainless	0.125	[illegible]	0.[illegible]	25/32	-[illegible]	DPDT 6A @ 125 VAC	$[illegible]	
		A[illegible] K[illegible]	2	[illegible]		Maint.	Bat	Passivated Stainless	0.20	[illegible]	63/64	[illegible]	-1 1/4	DPDT 6A @ 125 VAC	$[illegible]	
		A[illegible] K[illegible]	2	50		Mom.	Flat Tab	Passivated Stainless	[illegible]	[illegible]	63/64	15/16	-1 1/4	DPDT 6A @ 125 VAC	$[illegible]	[illegible]
		A[illegible] K[illegible]		[illegible]		Mom.	Bat	Passivated Stainless	[illegible]	[illegible]	[illegible]	[illegible]	-1 1/4	DPDT 6A @ 125 VAC	$[illegible]	
		T[illegible]	2	[illegible]		Maint.	Bat	Nickel Plated	[illegible]	21/64	15/32	Dia.	-1	DPDT [illegible]A @ 125 VAC	$[illegible]	Black handle avail. [illegible]
		T[illegible]	2	25° any [illegible]	2 lbs [illegible]	Mom.	Bat	Anodized Alum.	[illegible]	[illegible]	[illegible]	Dia.	-1 3/4	1 PDB 15A @ 120 VAC		[illegible]
		[illegible]	3	15°	[illegible]	Mom. [illegible] Maint.	Separated Bat	Black Plastic	[illegible]	[illegible]	15/32	[illegible]	-1 1/2	SPDT 10A @ 125 VAC		
4-Way		[illegible]	5	20	[illegible]	4 Mom. Quad Center Maint.	Stepped Round Knob	[illegible] Red Plastic	[illegible]	[illegible]	1 1/32	Dia.	[illegible]	SP[illegible]T 10A @ 125 VAC		
		T[illegible]	2	14°		Maint.	Long Bat	Nickel Plated	[illegible]	[illegible]	15/32	Dia.	-1	DPDT [illegible]A @ 125 VAC		Black handle avail.
		T[illegible]	2	14		Mom.	Bat	Nickel Plated	[illegible]	2[illegible]	9/16	Dia.	[illegible]	DPDT [illegible]A @ 125 VAC		[illegible] Black handle [illegible] not available
		A[illegible] K[illegible]	2	50°		Mom.	Flat Tab	Satin Chrome	[illegible]	[illegible]	63/64	15/16	-1 1/4	DPDT 6A @ 125 VAC		[illegible]
		A[illegible]	3	[illegible]		Maint.	Bat	Passivated Stainless	[illegible]	[illegible]	21/32	1 1/8	[illegible]	[illegible]PDT [illegible]A @ 125 VAC		
	[illegible]	[illegible]	4			1 [illegible] Mom. [illegible] Maint.	Bat	[illegible] Nickel		[illegible]	1 3/8	2 1/8	[illegible]	SPST 15A @ 115 VAC		[illegible] MS-2[illegible]
		[illegible]	3			1 Side Mom. 1 Side Maint.	Bat	[illegible] Nickel		[illegible]	3/4	1 5/16	-1 1/4	DPDT 10A @ 115 VAC	$1.40	[illegible]AN-S-2[illegible]
		[illegible]	2			Maint.	Bat	[illegible] Nickel		[illegible]	3/4	1 5/16	-1 1/4	DPDT 10A @ 115 VAC	$1.12	[illegible]AN-S-2[illegible]

TOGGLE SWITCHES

SHEET 2 OF 3

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]			[illegible]	[illegible]	[illegible]
							STYLE	FINISH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	[illegible] Hammer	[illegible]	[illegible]	19° ±6°		1 Side Mom 1 Side Maint	Bat	Dull Nickel		[illegible]	63/64	5/16	1 5/8	DPDT 25 A @ 115 VAC		MS 25[illegible]
		[illegible]	2	16° ±6°		Maint	Bat	Dull Nickel		11/16	63/64	5/16	1 5/8	[illegible]PDT 25 A @ 115 VAC		MS 25[illegible]-21
		[illegible]	[illegible]	21 ±[illegible]		1 Side Mom 1 Side Maint	Bat		0	[illegible]	[illegible]	[illegible]	[illegible]	DPDT 1 A @ 115 VAC		
		[illegible]	2	[illegible]		Maint	Bat		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DPDT 1 A @ 115 VAC	$[illegible]	
	[illegible]	[illegible]	2			Maint	Bat				1/2	2 [illegible]	[illegible] 7/8	4 PDT [illegible]	$7.90	Form [illegible] contacts [illegible]
		[illegible]	2			Maint	Bat				[illegible]	2 3/8	[illegible] 7/8	16 PDT 3A, 115 V	$46.0[illegible]	Form C contacts
	[illegible]	[illegible]	2		Open 95 gm Close 95 gm	Maint	Straight Round		[illegible]	[illegible]	2.625	1 15		DPDT 10A @ 125VAC		
	[illegible]	[illegible]	2	60°		Maint	Bat		0	[illegible]	21/32	25/32	[illegible]	DPDT 5A @ 125VAC		
		[illegible]	2	60°		Maint	Bat		[illegible]	[illegible]	21/32	25/32	[illegible]	DPDT 5A @ 125VAC		
		[illegible]	2	[illegible]		Maint	Bat		[illegible]	[illegible]	[illegible]	[illegible]	1 1/2	DPDT 5A @ 125 VAC		
		[illegible]	[illegible]	[illegible]		Side Mom [illegible] Side Maint	Bat		[illegible]	[illegible]	[illegible]	[illegible]	1 1/2	DPDT 5A @ 115 VAC		
		[illegible]	[illegible]	[illegible]	[illegible]	4 Mom Quad [illegible] Maint	Bat		[illegible]	[illegible]	1 29/64	1 29/64	1 3/8	4 DPDT 5A @ 125 VAC		4-way action MIL-S-6743.
		[illegible]	[illegible]	[illegible]	[illegible]	4 Mom Quad [illegible] Maint	Bat		[illegible]	[illegible]	1 29/64	1 29/64	1 3/8	4 DPDT 5A @ 125 VAC		4-way action MIL-S-6743.
[illegible] Switch	[illegible]	[illegible]	[illegible]	20°	[illegible]	4 Mom Quad [illegible] Maint	Bat	Satin Nickel	[illegible]	[illegible]	[illegible]	[illegible]	2 1/2	4 1PDB 10A @ 30 VDC	$18.5[illegible]	4-way action MIL-S-[illegible]
	[illegible]	[illegible]	2	20°	[illegible]	Maint	Bat	Dc Plating	[illegible]	11/16	11/16	1 1/4	1 3/8	DPDT 5A @ 125 VAC		MS 25[illegible]
		[illegible]	2	36° [illegible]	[illegible]	Maint	Bat	Dc Plating	[illegible]	11/16	11/16	1 1/4	1 9/32	DPDT 5A @ 125 VAC	$[illegible]	
	[illegible]	[illegible]	2	32		Maint	Bat		[illegible]		21/32	25/32	[illegible] 1 1/2	2 PDB 10A @ 250 VAC	$7.[illegible]	
		[illegible]	2	32°		Maint	Bat		[illegible]		21/32	25/32	[illegible] 1 1/2	2 PDB 10A @ 250 VAC	$7.[illegible]	

TOGGLE SWITCHES

SHEET 3 OF 3

TRADE NAME	MFG CODE	MODEL NUMBER	NO. POS.	DISPLACEMENT	OPERATING FORCE	SWITCHING ACTION	HANDLE STYLE	HANDLE FINISH	HANDLE DIA (IN.)	HANDLE LENGTH (IN.)	BEHIND PANEL WIDTH (IN.)	BEHIND PANEL LENGTH (IN.)	BEHIND PANEL DEPTH (IN.)	ELECTRICAL CONFIGURATION	PRICE	COMMENTS ON SPECIAL FEATURES
	[illegible]	5656	3	[illegible]	[illegible]	4 Mom. Quad Center Mount	Straight Round Bar	Phenolic	1/4	[illegible]	1 13/32	2 3/4	[illegible]	[illegible] 25A @ 28 VDC	[illegible]	4-way action
		5667A	3	[illegible]	[illegible]	[illegible] Center Mount	Straight Round Bar	[illegible]	1/4	[illegible]	[illegible]	2 3/32	[illegible]	SPDT 20A @ 28 VDC	[illegible]	[illegible]
		666161	3	[illegible]	[illegible]	[illegible] Center Mount	Stepped Round Knob	[illegible]	[illegible]	[illegible]	[illegible]	Dia	[illegible]	[illegible]	[illegible]	4-way action
		666151	3	[illegible]	[illegible]	[illegible] Center Mount	Straight Round Bar	Black Phenolic [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4-way action [illegible]
	[illegible]	[illegible]	[illegible]			Maint.	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	DPDT [illegible] VAC		
		[illegible]	[illegible]			[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	DPDT 15A @ [illegible] VAC		
	[illegible]	[illegible]	2	[illegible]	[illegible]	Maint.	Bat		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DPDT [illegible]	[illegible]	MS [illegible]
		[illegible]	[illegible]	[illegible]		[illegible]	Bat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	2	[illegible]	[illegible]	Maint.	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		[illegible]	2	[illegible]	[illegible]	Maint.	Bat	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Tab Indicator		[illegible]	[illegible]	[illegible]		[illegible]	Wedge Tab	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DPDT [illegible]	[illegible]	
Tab Indicator		[illegible]	[illegible]	[illegible]	[illegible]	Maint.	Wedge Tab	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Electrical Memory		[illegible]	[illegible]	[illegible]		[illegible]	Bat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4 SPDT [illegible] VAC	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	Maint.	Bat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4 SPDT [illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Maint.	Bat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Bat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DPDT [illegible] VAC	[illegible]	
		[illegible]	[illegible]	[illegible]	[illegible]	Maint.	Bat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Bat	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		[illegible]	2	[illegible]		Maint.	Wedge		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4 SPDT [illegible] VAC		[illegible]
	[illegible]	[illegible]	2	[illegible]		Maint.	Bat		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DPDT [illegible] VAC	[illegible]	
		[illegible]	2	[illegible]		Maint.	Bat		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DPDT [illegible] VAC	[illegible]	

LEVER SWITCHES

SHEET 1 OF 2

TRADE NAME	MFG CODE	MODEL NUMBER	NO. POS.	DISPLACEMENT	OPERATING FORCE	SWITCHING ACTION	HANDLE				BEHIND PANEL DIMENSIONS			ELECTRICAL CONFIGURATION	PRICE	REMARKS OR SPECIAL FEATURES
							STYLE	FINISH	END DIA (IN.)	LENGTH (IN.)	W (IN.)	L (IN.)	D (IN.)			
	[illegible]	[illegible]		[illegible]		Various Combinations Available	[illegible] Screw On	Glass Plastic Black	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Various Leaf [illegible] VA		Alternate Handles Avail. [illegible] Rocker Type
		[illegible]	[illegible]	[illegible]		Various Combinations Available	Standard Screw On	Glass Plastic Black	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Various Leaf [illegible] VAC		Alternate Handles Avail. [illegible] Rocker Type
		[illegible]		[illegible]		Various Combinations Available	[illegible] Screw On	Glass Plastic Black	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Various Leaf [illegible] VAC		Alternate Handles Avail. [illegible] Rocker Type
	[illegible]	[illegible]	[illegible]	[illegible]		Various Combinations Available	Square [illegible]	Glass Plastic Black			[illegible]	[illegible]	[illegible]	Various Wafer [illegible]		
	[illegible]					Locking	[illegible] Screw On	Glass Plast. Blk, Red, Wt or Gr.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2 Form [illegible] 115 VA [illegible]	[illegible]	Other Contacts and Actuators Available
		[illegible]				[illegible] Locking	[illegible] Screw On	Glass Plast. Blk, Red, Wt or Gr.	[illegible]		[illegible]	[illegible]	[illegible]	4 Form [illegible] VAC [illegible]	[illegible]	Other Contacts and Actuators Available
	[illegible]	[illegible]	[illegible]	[illegible]		Various Combinations Available	Bat Screw On	[illegible] Black	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Various Leaf [illegible]	$[illegible] Plus Contacts	[illegible] Handles Available
		[illegible]		[illegible]		Various Combinations Available	Bat Screw On	[illegible] Black	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Various Leaf [illegible]	$[illegible] Plus Contacts	[illegible] Handles Available
		[illegible]				Various Combinations Available	Bat Screw On	[illegible] Black	[illegible]	[illegible]	[illegible]	[illegible]		Various Leaf [illegible]	$[illegible] Plus Contacts	[illegible] Handles Available
		[illegible]		[illegible]		Various Combinations Available	Standard Screw On	[illegible] Black	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Various Leaf [illegible]	$[illegible] Plus Contacts	[illegible] Handles Available
		[illegible]		[illegible]		Various Combinations Available	[illegible] Screw On	[illegible] Black	[illegible]		[illegible]	[illegible]	[illegible]	Various Leaf [illegible]	$[illegible] Plus Contacts	[illegible] Handles Available
		[illegible]		[illegible]		Various Combinations Available	[illegible] Screw On	[illegible] Black	[illegible]		[illegible]	[illegible]	[illegible]	Various Leaf [illegible]	$[illegible] Plus Contacts	[illegible] Handles Available [illegible]
							Not Supplied				[illegible]	[illegible]	[illegible]			
	[illegible]	[illegible]				[illegible]	Not Supplied				[illegible]	[illegible]	[illegible]	[illegible] Pole Wafer [illegible]		Lever Shaft [illegible]
		[illegible]	[illegible]			[illegible]	Not Supplied				[illegible]	[illegible]	[illegible]	[illegible] Pole Wafer [illegible]		Lever Shaft [illegible]
		[illegible]				[illegible]	Not Supplied				[illegible]	[illegible]	[illegible]	[illegible] Pole Wafer [illegible]		Lever Shaft [illegible]
		[illegible]	[illegible]			[illegible]	Not Supplied				[illegible]	[illegible]	[illegible]	[illegible] Pole Wafer [illegible]		Lever Shaft [illegible]
		[illegible]		[illegible]		[illegible]	Not Supplied				[illegible]	[illegible]	[illegible]	[illegible] Pole Wafer [illegible]		Lever Shaft [illegible]
		[illegible]				[illegible] Spring Return [illegible]								[illegible] Pole Wafer [illegible]		Lever Shaft [illegible]
							Not Supplied				[illegible]	[illegible]	[illegible]			
	[illegible]				[illegible]	[illegible]	Not Supplied				[illegible]	[illegible]	[illegible]	[illegible] Pole Wafer [illegible]		Multiple Decks Available [illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Not Supplied				[illegible]	[illegible]	[illegible]	[illegible] Pole Wafer [illegible]		Multiple Decks Available [illegible]
		[illegible]			[illegible]	[illegible]	[illegible]	Black			[illegible]	[illegible]	[illegible]	[illegible] Pole Wafer [illegible]		Multiple Decks Available [illegible]
		[illegible]		[illegible]		Locking								2 Pole Wafer [illegible]	$[illegible]	Other Models [illegible]

* [illegible]

LEVER SWITCHES

SHEET 2 OF 2

TRADE NAME	MFG CODE	MODEL NUMBER	NO. POS.	DISPLACEMENT	OPERATING FORCE	SWITCHING ACTION	HANDLE STYLE	HANDLE FINISH	HANDLE END DIA (IN.)	HANDLE LENGTH (IN.)	BEHIND PANEL DIMENSIONS WIDTH (IN.)	BEHIND PANEL DIMENSIONS LENGTH (IN.)	BEHIND PANEL DIMENSIONS DEPTH (IN.)	ELECTRICAL CONFIGURATION	PRICE	REMARKS OR SPECIAL FEATURES
	.PT	MS-14-1L4F-2	6	[illegible]			Tab	Black			13/16	1 5/8	1 5/8	2 Pole wafer 1A @ 125 VAC	$ 1.90	
		MS-26-1L5A-1	5	[illegible]			Cylindrical Screw On	Black			- 3/4	-2 5/8	- 2 3/4	2 Pole wafer 1A @ 125 VAC	$ 3.25	
		MS-26-1L4A-1	[illegible]	30°			Cylindrical Screw On	Black			- 3/4	-2 5/8	- 2 3/4	2 Pole wafer 1A @ 125 VAC	$ 3.50	
	Mallory	7225-C	[illegible]	20			Not Supplied				3/4	2 1/8	1 15/16	1 to 3 Pole wafer 6.12A@110 VDC		Spring return available.
		5226	6	20°			Not Supplied				3/4	2 11/16	1 15/16	1 or 2 Pole wafer 6.12A @ 110 VDC		Spring return available
		6M Series	[illegible]	14°			Tab	Black					1 1/4			Spring return available
	Micro-mac	Series 4701	2 or 3	2°	1.5 lb at end of handle	Locking or Non-Locking	Bat Screw on	Black Phenolic	.5/16	.7/8	5/8	3/4*	2 7/16	Various Leaf 5A @ 110 VAC	$ 2.06 Plus Contacts	Colored handles available
		Series 4901	2 or 3	21°	1.5 lb at end of handle	Locking or Non-Locking	Bat Screw on	Black Phenolic	.5/16	.7/8	3/8	3/4*	2 1/4	Various Leaf 5A @ 115 VAC	$ 2.75 Plus Contacts	Colored handles avail.
		Series 4200	2 or 3	15° Locking 30° Non-Locking	1.5 lb at end of handle	Locking or Non-Locking	Cylindrical Screw on	Black Phenolic	.5/16	.7/8	1 1/8	1 7/16*	1 1/2	Various Leaf 5A @ 110 VAC	$3.50 Plus Contacts	Colored handles available
	OAK	105	5	[illegible]°		Locking Spring Return Optional	Not Supplied				9/16	2 11/16	1 29/32	1 to 3 Pole wafer 0.5A @ 110 VAC		Other models available
		190	6	30°		Locking Spring Return Optional	Not Supplied				5/16	1 1/2	1.637	1 to 6 Pole wafer 0.5A @ 110 VAC		For ganging applications
		187	2	6°		Locking Spring Return Optional	Not Supplied				.9/16	1 7/8	1 3/8	Multi-Pole wafer 0.5A @ 110 VAC		All tab levers handle have 0.107 x 0.250 in. cross section
		167	[illegible]	45°		Locking Spring Return Optional	Not Supplied				.9/16	1 7/8	1 3/4	Multi-Pole wafer 0.5A @ 110 VAC		
	Switchcraft	[illegible]	2	16		Non-Locking	Cylindrical Screw on	Black Plastic	.5/16	.7/8	5/8	11/32	2 1/4	DPDT Leaf 3A @ 120 VAC	$ 2.75	Colored knobs avail., other models avail.
		9936L	1	16°		Locking	Cylindrical Screw on	Black Plastic	.5/16	.7/8	5/8	27/32	2 1/4	DPDT Leaf 3A @ 120 VAC	$ 2.90	Colored knobs avail. other models avail.
		36016	[illegible]	10° Locking 10° Non-Locking		Non-Locking (Remove Stop Plate to Make Locking)	Cylindrical Screw on	Plastic	.7/8	.1	.7/8	1 1/16*	3 1/32	DPDT Leaf 3A @ 120 VAC	$ 5.50	Other models available
		6616	[illegible]	15° Locking 20° Non-Locking		Non Locking (Locking in 62361)	Cylindrical Screw on	Plastic	.1 8	.1	.7/8	1 3/16*	3	DPDT Leaf 3A @ 120 VAC	$ 5.00	Other models available.
		Series 26000	2 or 3	60° Locking 20° Non-Locking		Locking or Non-Locking	Cylindrical Screw on	Plastic	.7/8	.1	.7/8	1 3/16*	3	Various Leaf 3A @ 120 VAC		Has push to lock and push to release features
		.156	1	[illegible]		Non-Locking (Locking in 23156)	Tapered Square	Black Plastic	7/32sq	1 2	.5/8	5/8	2 3/32	DPDT Leaf 3A AC	$ 2.10	Other models available
		Series 25000	2 or 3	16°		Locking or Non-Locking	Serrated Tapered Square	Translucent Plastic	5/32 x1 8	19/32	19/64	3 [illegible] 2	2 1/4	Various Leaf 3A AC		Illuminated handle all one time protected case, min. screw base

*May be increased by additional contact assemblies

SLIDE SWITCHES

TRADE NAME	MFG CODE	MODEL NUMBER	NO. POS.	DISPLACEMENT (IN.)	OPERATING FORCE	SWITCHING ACTION	HANDLE: STYLE	HANDLE: FINISH	HANDLE: END DIA. (IN.)	HANDLE: LENGTH (IN.)	MOUNTING PANEL DIMENSIONS: W (IN.)	MOUNTING PANEL DIMENSIONS: L (IN.)	MOUNTING PANEL DIMENSIONS: D (IN.)	ELECTRICAL CONFIGURATION	PRICE	REMARKS OR SPECIAL FEATURES
	Centralab	Series MZ	2 or 3	1/8 in. per Pos		Maintained	Not Supplied				.45	1 11/32	1.4	Various wiring 0.25A @ 115 VAC		Push pull action
	Continental Wirt	Slide Switches	2 or 3	~1/8 - 3/16 in. per Pos.		Maint or Mom	Square or High Bat	Phenolic Colors Avail	[illegible]	[illegible]	~.5	~1.5	~.7	Various 0.4 to 2A @ 125 V	~$ 2.25	Long tapered handle available
	Cutler-Hammer	8000	2			Maint	Serrated Wedge	Black Phenolic	5/16 x 1/4	15/64	15/32	2 5/32	1 3/64	SPDT 3A @ 125 VAC		Other models available
	OAK	Series 18	2 to 4			Maint	Not Supplied				1 5/8	25/32	2	2 to 20 Poles others, 1A @ 110 VAC		Pos. pos. action.
	Stackpole	SS-5	2	.07		Mom	Rect Serrated Top	Black Stand	.224 x .270	11/32	17/32	1.09	29/32	DPDT 0.5A @ 125 VAC	~$ 0.08	7/32 & 19/32 in. high handles and red handles available
		SS-55	2	.196		Mom	Rect Serrated Top	Black Stand	.224 x .270	11/32	17/32	1.175	5/8	DPDT 3A @ 125 VAC	~$ 0.40	7/32 & 19/32 in. high handles and colored handles available
		SS-26	3	.17		Maint	Rect Serrated Top	Black Stand	.224 x .270	11/32	17/32	1.09	29/32	DP 3 Pos. 3A @ 125 VAC	~$ 0.40	7/32 & 19/32 in. high handles and colored handles available
		SS-8	4	.18		Maint	Rect Serrated Top	Black Stand	.224 x .270	11/32	17/32	1.09	29/32	DP 4 Pos. 3A @ 125 VAC	~$ 0.40	7/32 & 19/32 in. high handles and colored handles available

ROCKER SWITCHES

SHEET 1 OF 1

TRADE NAME	MFG CODE	MODEL NUMBER	NO POS	DISPLACEMENT	OPERATING FORCE (OZ)	SWITCHING ACTION	ACTUATED KEY				MTG PANEL DIM			ELECTRICAL CONFIGURATION	PRICE	SAMPLE	REMARKS OR SPECIAL FEATURES
							STYLE AND COLOR	LENGTH IN	WIDTH IN	HEIGHT IN	LENGTH IN	WIDTH IN	DEPTH IN				
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]		X	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]		X	[illegible]
[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		X	
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]		[illegible]		X	[illegible]
[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]
	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]
	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		X	[illegible]
	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]
	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]			[illegible]
	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							

THUMBWHEEL SWITCHES

SHEET 1 OF 1

TRADE NAME	MFG CODE	MODEL NUMBER	NUMBER OF POSITIONS	OPERATING FORCE	SETTING TAB: DISPLACEMENT	SETTING TAB: STYLE	SETTING TAB: WIDTH (IN)	SETTING TAB: FINISH	CHARACTER: HEIGHT (IN)	CHARACTER: WIDTH (IN)	CHARACTER: STROKE (IN)	MODULE DIMENSIONS: LENGTH (IN)	MODULE DIMENSIONS: WIDTH (IN)	MODULE DIMENSIONS: DEPTH (IN)	BEZEL: FINISH	BEZEL: LENGTH (IN)	BEZEL: WIDTH (IN)	OUTPUT CODE	ELECTRICAL RATING	APPROX PRICE PER UNIT	REMARKS OR SPECIAL FEATURES
	[illegible]	TTMR				Sprocket Rt Side		[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	Binary	25 Ma @ [illegible]		[illegible]
		TTL				Sprocket Rt Side		Molded [illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	Binary [illegible]	25 Ma @ [illegible]		[illegible]
		MTTSR	[illegible]			Sprocket Rt Side		Molded [illegible]				[illegible]	[illegible]	[illegible]		1.910	[illegible]	Binary	25 Ma @ [illegible]		[illegible]
		TSB-[illegible]	[illegible]			[illegible]	[illegible]	Molded [illegible]				[illegible]	[illegible]	[illegible]				Binary	50K Ma @ [illegible]		[illegible]
[illegible]	[illegible]	Series [illegible]	[illegible]	[illegible]		Sprocket Rt Side						[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	Binary & Many Others	200 Ma, 200 V	$ [illegible]	[illegible]
		Series [illegible]	[illegible]	[illegible]		Sprocket Rt Side						[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	Binary & Others	200 Ma, 200 V	$ [illegible]	[illegible]
	[illegible]	[illegible]				Saw Tooth Left Side	[illegible]	[illegible]				[illegible]		[illegible]	Not Supplied	NA	NA	[illegible]	[illegible]		[illegible]
		[illegible]	[illegible]			Saw Tooth Bottom	[illegible]	[illegible]					[illegible]	[illegible]	Not Supplied	NA	[illegible]	Decimal	[illegible]		[illegible]
		[illegible]	[illegible]			Saw Tooth Bottom	[illegible]	[illegible]						[illegible]	Metal [illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
		SMT				Saw Tooth Rt Side	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	Not Supplied	NA	NA	[illegible]	[illegible]		[illegible]
		[illegible]	[illegible]			Sprocket Rt Side						[illegible]		[illegible]	Not Supplied	NA	NA	[illegible]			[illegible]
		[illegible]	[illegible]			Sprocket Rt Side								[illegible]	Not Supplied	NA	NA	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]				Sprocket Rt Side	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Binary	[illegible]	$ [illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Sprocket Rt Side			[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	Binary	[illegible]		[illegible]
	[illegible]		[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	None			Binary & [illegible]	[illegible]		[illegible]
			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	None			[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	None			Binary [illegible]		$ [illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sprocket [illegible]	[illegible]			[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Binary & [illegible]	[illegible]	$ [illegible]	[illegible]

PUSHBUTTONS—UNILLUMINATED

SHEET 1 OF 4

TRADE NAME	MFG CODE	MODEL NUMBER	DISPLACEMENT (IN.)	OPERATING FORCE	SWITCHING ACTION	INTERLOCKS	BUTTON SIZE: STYLE	BUTTON SIZE: SIZE (IN.)	BUTTON SIZE: HEIGHT (IN.)	BUTTON SIZE: FINISH	PANEL MOUNTING: LENGTH (IN.)	PANEL MOUNTING: WIDTH (IN.)	PANEL MOUNTING: DEPTH (IN.)	ELECTRICAL CONFIGURATION	PRICE	REMARKS OR SPECIAL FEATURES
	Allied Control	PM-7				None	Round Concave			White Nylon	.500	.500	5/8	3 PDT 1A @ 115 VAC	$ 6.30	Colored caps available
	Amer. Monarch	CC 7700	0.307 min. 0.200 max.	900gm. w/o interlock 1100gm. w interlock		Various Incl. Matrix	Rect. Flat	.625 x .750		White Dyrene	5/8*	3/4*	1 15/16	Various Load 2A @ 115 VAC		Solenoid release & elect. lockout avail. Strip switches
	Capital Machine	B-Series	5/16 Full Travel 1/4 Lock in			Various Incl. Matrix	Round Concave	31/64 Dia.	1/2	Colored Plastic	1/2 to 1 1/2*	5/8*	2 9/16	Various Load 3A @ 110 VAC		Strip switches various alternate buttons.
		D-Series	7/16 Full Travel 1/4 Lock in			Various Incl. Matrix	Round	31/64 Dia.	1/2	Colored Plastic	1/2 to 1 1/4*	3/4*	1 3/4	Various Load 3A @ 110 VAC		Strip switches various alternate buttons.
		E-Series	3/8			Various	Round	31/64 Dia.	1/2	Colored Plastic	3/4*	3/4*	2 5/8	Various Load 3A @ 110 VAC		Strip switches various alternate buttons.
		PLB	13/32 Full Travel 5/16 Lock in		Alternate	None	Round	31/64 Dia.	1/2	Colored Plastic	7/8	33/16	1 7/8	Various Load 3A @ 110 VAC		
		PS	5/32		Momentary	None	Round	31/64 Dia.	1/2	Colored Plastic	5/8	9/16	2 5/16	Various Load 3A @ 110 VAC		
		PSA	5/32		Momentary	None	Round	31/64 Dia.	1/2	Colored Plastic	5/8	9/16	2 1/2	Various Load 3A @ 110 VAC		
Push Key	Capre	HM-60			Momentary	None	Round	7/16 Dia.	~1/4	Black or Gray Nylon	27/32	9/16	3 1/8	2 Form C 1A @ 110 VAC		
Push Key		HL-60			Alternate	None	Round	7/16 Dia.	~3/8	Black or Gray Nylon	27/32	9/16	3 1/8	2 Form C 1A @ 110 VAC		[illegible] push-pull action.
Code Bar Switches	Computer Control	DB-1	5/16	12 oz		Interlock One at a time	Round Angle Top	3/8 Dia.		Plastic	5/8	5/8*	1 1/2	1-2-4-8 BCD 10A @ 125 VAC	$87.50 10 Buttons	Ten button decimal, [illegible] eight button octal & parity available
	Control Switch	A4-300-[illegible] E4-111			Momentary Positive Feel	None	Round Concave	20/32 Dia.	3/16	Red Plastic other colors	43/64	21/32	1 3/4	2 PDT 5A @ 125 VAC		
		A4-297 B1-6	P.T. .568 O.T. .250 M.D. .026 .318	Operating 20 oz Overtravel [illegible]	Momentary	None	Round	.625 Dia.	[illegible]	Red Plastic other colors	53/64	1 1/4	~1 3/8	SPDT DB 10A @ 125 VAC	$ 1.09	
		A4-67/ D6-4	P.T. .050 O.T. .035 M.D. [illegible] .065	~12 oz ± 1 oz	Momentary	None	Round Concave	1 Dia.	33/64	Black Plastic	2	1 1/2	1 27/64	SPDT DB 16A @ 125 VAC	$30.25	Red & green buttons available Knurled bushing 1 1/2 Dia. x 5/32
		A4-102-[illegible]/ D6-4	P.T. .050 O.T. .035 M.D. [illegible] .065	~12 oz ± 1 oz	Momentary	None	Round Concave	1 Dia.	11/32	Green Plastic	2	1 1/2	1 27/64	SPDT DB 16A @ 125 VAC	$16.25	Red & black buttons available. Knurled button guard 1 1/2 Dia. x 5/8.
		A4-36-0/ D6-4	P.T. 5/64 O.T. 1/8 M.D. .020 21/64	Operating 30 oz Total Travel 5/16	Momentary	None	Round Concave	5/8 Dia.	13/16	Black Plastic	1 1/4	15/16	2 11/16	SPDT 15A @ 125 VAC	$ 7.90	Snap on button.
		C 136P3	.005	1 1/2 lb ± 1/2 lb	Momentary	None	Round Flat	3/8 Dia.	9/16	Red, Wt., [illegible] Plastic	7/8	Dia.	7/8	SPDT 10A @ 120 VAC	$ 3.70	Flange adapter 7/8 Dia. [illegible] or black, other buttons.
		H 2264U3		3 lb ± 1 lb	Momentary	None	Round Flat	3/8 Dia.	9/16	Red, Wt., Black Plastic	5/8	1	1 1/4	SPDT DB 10A @ 120 VAC	$12.15	Flange adapter 7/8 Dia. [illegible] or black, other buttons.
		W 3037	.005	4 lb ± 1 lb	Momentary	None	Round Flat	11/32 Dia.	3/16	Colored Plastic	11/16	Dia.	1 7/16	SPDT DB 16A @ 120 VAC		
		B 3036			Non-Snap Momentary	None	Round	9/16 Dia.	3/8	Black, Gr. or Red Plastic	11/16	Dia.	~1 3/8	SPDT DB 3A @ 28 VDC	$ 3.[illegible]	Removable button for keyboards.
		WC 1506	.005	5 lb ± 1 lb	Momentary	None	Round	3/8 Dia.	29/32	Colored Plastic	11/16	Dia.	~1	DPDT DB 2A @ 28 VDC		Operating pressures of 2 oz. and 5 ± 1 lb available.
		C 2067	.005	1 1/2 lb ± 1 lb	Push - Pull	None	Round	5/16 Dia.	15/32	Black Plastic	11/16	Dia.	~1	SPDT DB 15A @ 120 VAC		

O.T. Over Travel
P.T. Pre Travel
M.D. Movement Differential

* Per Station

PUSHBUTTONS—UNILLUMINATED

Trade Name	MFG	Model Number	Replacement (in.)	Operating Force	Switching Action	Inter-Lock	Button (Key): Style	Size (in.)	Height (in.)	Color	Panel Cutout: Length (in.)	Width (in.)	Depth (in.)	Electrical Configuration	Cost	Remarks or Special Features
	Control Switch	C2001	305	4 lb ± 1 lb		None	Round	3/8 Dia.	5/16	Red, White, or Black Plastic	7/8	Dia.	1 5/16	SPDTDB 15A @ 120 VAC	$4.[illegible]	Anodized Aluminum adapter.
		W9681	305	4 lb ± 1 lb		None	Round Convex	7/8 Dia.	~1/8	Various Colors	7/8	Dia.	1 9/16	SPDTDB 15A @ 120 VAC		
		23336	11/64	2 1/4 lb ± 1 lb	Push-Push (Alternate)	None	Round	3/8 Dia.	9/16	Various Colors	7/8	Dia.	1 1/4	DPDT 1A @ 120 VAC	$6.98	Anodized aluminum flange adapter
	Electronic Controls	691-4			Momentary	None	Round Concave				1 1/4	1 1/32	~ 1/4	4 PDT 3A, 125 V	$3.50	
		973-161			Momentary	None	Round Concave				1 1/4	1 1/32	~ 3/4	36 PDT 1A, 125 V	$25.34	
	General Control	MPB			Positive Feel	Various (Incl. Mutual)	Round Convex	[illegible] Dia.	[illegible]	Various Colors	[illegible]	[illegible]	3 15/16	Various load 1 to 5A @ 125 VAC	~$2.50 Per Button	Right angle unit available. Solenoid release avail.
		SPB			Positive Feel	Various (Incl. Mutual)	Round Flat	7/16 Dia.	~ 11/16	Various Colors	[illegible]	5/8	2 5/8	Various load 1 to 1A @ 125 VAC	~$3.5[illegible] Per Button	Solenoid Release Available.
	Grayhill	2252	P.T. 367; 305 C.T. 325	Operating [illegible]	Snap-Action Momentary	None	Round Concave	.31 Dia.	.20	Black Plastic	.67	Dia.	1 1/4	SPDT 1/2A @ 115 VAC	$1.79	Sample. Audible click. 1" Dia. x 3/4 concave button, flange adapter & button guard available.
		0982	137	25±5 [illegible]	Momentary	None	Round Concave	.31 Dia.	.14	Black Plastic	.60	Dia.	1 37	SPST 1A @ 115 VAC	$2.71	Sample. Red button available.
		15-1	390	16 [illegible]	Momentary	None	Round Concave	.34 Dia.	.19	Red Button	.76	Dia.	[illegible]	DPST 1/2A @ 115 VAC	$1.[illegible]	Sample
		21-1	390	[illegible]	Momentary	None	Round Concave	.30 Dia.	.33	Red Button	.56	Dia.	2 3/8	SPST 1/4A @ 115 VAC	$2.05	Sample
		17	365	17 oz	Momentary	None	Round Concave	.5 Dia.	.33	Red Button	.17	Dia.	[illegible]	SPST 1A @ 115 VAC	$2.99	Sample. Colored button caps [illegible]
		37-16	161	Oper. [illegible] Rotary [illegible]	Push-Push	None	Round Concave	[illegible] 16 Dia.	.69	Red Button	[illegible]	Dia.	[illegible]	SPST 1A @ 115 VAC	$1.15	
		39-12	P.T. 205; 150 C.T. 345	5 oz	Momentary	None	Round Concave	.31 Dia.	~ 3/16	Red Button	.25	Dia.	[illegible]	SPST 1/2A @ 115 VAC	$1.15	Colored button caps [illegible]
	Grigsby	3939	3/16		Momentary (Alter. Avail.)	None	None				1	[illegible]	1 17/32	DPDT 1A @ 115 VAC		
		13 M	261			Interlock	Rect. Concave	5/16 x .050	[illegible]/32	Black Plastic	[illegible]	3/8	[illegible]	[illegible] PDT 1A @ [illegible] VAC		
	Haydon	53697			Momentary	None	Round Concave	.343 Dia.	1/8	Black Plast.	13/16	[illegible]	[illegible]	DPDT 5A @ 115 VAC		Red or white button available
		53723			Momentary Positive Action	None	Round Concave	.323 Dia.	.190	Red Plast.	25/32	41/64	1 29	DPDT 5A @ 115 VAC		
		53769			Alternate	None	Round Concave	.323 Dia.	.190	White Plast.	25/32	[illegible]/32	[illegible]	DPDT 5A @ 115 VAC		

PUSHBUTTONS—UNILLUMINATED

TRADE NAME	MFG	MODEL NUMBER	DISPLACEMENT (IN.)	OPERATING FORCE	SWITCHING ACTION	INTERLOCK	BUTTON (KEY): STYLE	BUTTON (KEY): SIZE (IN.)	BUTTON (KEY): HEIGHT (IN.)	BUTTON (KEY): FINISH	PANEL DIMENSIONS: LENGTH (IN.)	PANEL DIMENSIONS: WIDTH (IN.)	PANEL DIMENSIONS: DEPTH (IN)	ELECTRICAL CONFIGURATION	PRICE	REMARKS OR SPECIAL FEATURES
	Lever	PSW-[illegible]				None	None				713	680	[illegible]	Photoelectric [illegible]	[illegible]	Transistor [illegible] mounting [illegible] avail.
	ITT	[illegible]		250 gm		None	Round Concave							Various Load 3 A	~$5.00	Two [illegible] button magnetic hold.
	Licon	[illegible]	[illegible]	14 oz	Momentary	None	Round Concave	.166 Dia	[illegible]	White Nylon	[illegible]	[illegible]	[illegible]	DPDT DB 1 A @ 250 VAC	~$3.50	
	Micro Switch	2PB[illegible] T2	[illegible]	36 oz	Momentary Snap Action	None	Round Concave	[illegible]	[illegible]	Black	.78	[illegible]	[illegible]	DPDT 1 A @ 125 VAC	$6.40	
		6/PB[illegible] T2	[illegible]	Actuate [illegible] oz Release [illegible] oz	Alternate	None	Round Concave	.321 Dia	.19	Red	.78	.680	[illegible]	DPDT 1 A @ 125 VA	$7.40	
		2PB6	[illegible]	40 oz	Momentary	None	Round Flat	.56 Dia	[illegible]	Black Anod. Alum.	[illegible]	.472	.90	DPDT 1 A @ 125 VA	$7.[illegible]	Panel seal of button [illegible]
		1PB61	[illegible]	30 oz	Momentary	None	Round Flat	[illegible]	[illegible]	Red	.81	.62	.90	SPDT 1 A @ 125 VA	$5.[illegible]	Panel sealed button.
		1PB81 T2	.250	5 oz	Momentary	None	Round Concave	.50 Dia	.2	White Plastic	.78	[illegible]	[illegible]	SPDT 1 A @ [illegible]	$6.[illegible]	For keyboards [illegible]
		12 MA1 BZ-7B	Depends upon Panel Thickness	15 + 21 oz	Momentary Snap Action	None	Base Flat	[illegible] Dia		Green Plastic	1.00	.84	[illegible]	SPDT 15 A @ 125 VAC	$4.82	Knurled round nut 1.00 Dia.
		12 MA[illegible] 61TB[illegible]	Depends upon Panel Thickness	26 + 42 oz	Momentary Snap Action	None	Round Flat	1 Dia		Black Plastic	[illegible]	[illegible]	[illegible]	SP	$12.50	Knurled round nut [illegible] Dia.
		[illegible]PB1	[illegible]	22 oz	Momentary Snap Action	None	Round Concave	.90 Dia	.06	Black Plastic	[illegible]	[illegible]	[illegible]	SPDT 15 A @ 250 VAC	$1.[illegible]	
	[illegible]	Series [illegible]	[illegible]	[illegible]		Interlock or non-lock	Round Concave	[illegible] Dia	[illegible]	Black Anod. Alum.	[illegible]	Depends on # units	[illegible]	Various Load 1 A @ [illegible] VA	[illegible] Per Station	
		Series [illegible]	[illegible]	8 oz	Momentary push-[illegible]	None	Round	7/16 Dia	[illegible]	Black Plast.	[illegible]	[illegible]	2 29/32	Various Load 1 A @ 115 VA	[illegible]	
	[illegible]	Type 175	[illegible] Total [illegible] Detent		Momentary or alternate	None	None				[illegible]	[illegible]	[illegible]	1-4 Pole DT 1 A @ [illegible] VA		Slide [illegible]
		Type 130	[illegible] Total [illegible] Detent			Various	None				[illegible]	[illegible]	[illegible]	1-6 Pole 1 A @ 115 VA		Slide [illegible]
		Type 131	[illegible]			Interlock	None				[illegible]	.64	[illegible]	1-6 Pole 1 A @ 115 VA		Slide [illegible]
	[illegible]	[illegible]			Momentary	None	Round	7/16 Dia	13/64		[illegible]	Dia	[illegible]	DPST		
		[illegible]			Locking	None	Round	7/16 Dia	[illegible]		[illegible]	Dia	[illegible]	DPST		
		[illegible]			Momentary	None	Round	5/8 Dia	15/32		[illegible]	Dia	[illegible]	SPDT DB		
		[illegible]			Latching	None	Round	5/8 Dia	15/32		[illegible]	Dia	[illegible]	SPDT DB		

PUSHBUTTONS-UNILLUMINATED

SHEET 4 OF 4

Trade Name	Mfr	Model Number	Displacement (in.)	Operating Force	Switching Action	Interlocks	Button Unit: Style	Size (in.)	Height (in.)	Finish	Panel Dimensions: Length (in.)	Width (in.)	Depth (in.)	Electrical Configuration	Price	Remarks or Special Features
	[illegible]	1001	3/16		Momentary	None	Round Concave	1/4 Dia.	3/8	Colored Plastic				SPDT 2A @ 125 VAC		Light touch for keyboard applications.
	PE PC	8000[illegible]	.093	30 ± 2 oz	Momentary	None	Round Concave	9/16 Dia.	9/16		.917	Dia.	1 1/32	3 PDT 5A @ 28VDC		7/8 Dia. Snap nut.
Button Switch	Switchcraft	901			Momentary	None	Round	5/16 Dia.	11/64	Red or Black Plastic	7/8	Dia.	1 1/32	SPDT .5A, 25 watts	$1.57	17/32 Dia. flange
		11996			Push-Pull	None	Round Groove	7/16 Dia.	5/8	Black Plastic	13/16	9/16	2 7/8	2 form C leaf 3A, 300 watts	$5.50	
		11996			Momentary	None	Round	7/16 Dia.	3/8	Black Plastic	11/16	9/16	2 7/8	2 form C leaf 3A, 300 watts	$5.30	
		Series 9000	1/8			Various	Round Convex	1/2 Dia.	1/2	Plain Plastic	1 5/8	5/8	3 5/16	Various leaf 3A, 300 watts	~3.50 Per Button	3/4 in. button spacing available in series 800C, eq. button available.
		5090	1/4 Total 1/8 Detent		Alternate with Detent	None	Square Concave	1/2 x 1/2	1/2	Black Plastic	1 1/8	5/8	2 7/8	2 form C leaf 3A, 300 watts	$6.75	Momentary action available 5500.
	Switch Controls	Model 18	1/4 Total or 1/32			Various	Round	7/16 Dia.	5/8		1 Min.	5/8*	2 5/8	Various Leaf 3A		3/4 in. spacing available in model 11
	[illegible]	130071	6 ± 1 lb		Momentary Snap Action	None	Round	.375 Dia.	.250	Black or Red Plastic	.875	Dia.	1.09	SPDT 10A @ 28 VDC	$2.61 Lots of 100	Incl. 7/8 dia. black flange adapter. Other elect. & mounting config. avail.
	[illegible]	2823	1/4	1.5 lb	Momentary	None	Round Convex	21/64 Dia.	1/8	Black or Red Plastic	29/32	43/64	1 1/8	DPDT 5A @ 125 VAC		
Feather Touch	[illegible]	2831-1	1/8	2 oz	Momentary	None	Round Flat	9/16 Dia.	5/16	Plastic	1.09	.65	1 1/2	DPDT 5A @ 125 VAC		
	[illegible]	2636-1D		30 oz	Momentary Snap Action	None	Round Concave	21/64 Dia.	3/16	Black Plastic	29/32	21/32	1 5/16	DPDT 5A @ 125 VAC	$5.00	Red & green buttons available
Piano Key	[illegible]	7-233	9/32	6 ± 2 oz	Momentary	None	Rect Flat	~3/8 x ~1 1/2	~5/16	Colored Plastic	~2 1/4	~3/8	~1	SPDT		Button resembles piano key & pivots on back edge, barrier 1 edge.
	Chicago Dynamics	PBS-BN-13			Sequential 10 Position	None	Round Flat	5/8 Dia.			3.25	.904	2 29/32	4 Bit(Binary) 2A		3/8" high numerals appear in window. Switch advances one position for each push on the button. [illegible] and [illegible] display words available.

ILLUMINATED PUSHBUTTONS

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]				[illegible]			[illegible]	[illegible]	[illegible]
							[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	[illegible]	[illegible]	[illegible]	[illegible]	Momentary	None	1PC	Full Button		1 Short Base	Square Flat	[illegible]	[illegible]	Plastic	.750	.750	[illegible]	DPDT 5A @ 125 V	$11.50	Matrix Mount
		[illegible]	[illegible]	[illegible]	Alternate	None	1PC	Full Button		1 Short Base	Square Flat	[illegible]	[illegible]	Plastic	.750	.750	[illegible]	DPDT 5A @ 125 V	$16.25	Matrix Mount
		[illegible]	[illegible]	[illegible]	Momentary	None	1PC	Full Button		4 T 1 3/4 Mid. Grv.	Rect Flat	[illegible]	.37	White Plastic	1.50	1.13	5.00	DPDT 5A @ 125 V	$15.00	Integral Touch Anodized Barriers on Front Flange.
		[illegible]	[illegible]	[illegible]	Alternate	None	1PC	Full Button		4 T 1 3/4 Mid. Grv.	Rect Flat	[illegible]	.37	White Plastic	1.50	1.13	[illegible]	DPDT 5A @ 125 V	$18.50	Integral Black Anodized Barriers on Front Flange.
	[illegible]	[illegible]	[illegible]	[illegible]		Various		Full Button		1 T 1 3/4 Mig. Grv.	Rect Flat	[illegible]		Colored Plastic	5.00	[illegible]	[illegible]	Various Leaf 2A @ 115 VDC		Sectional Bezels and Lockout Avail. 1 Piece Button Incl. Filters
	[illegible]	[illegible]		[illegible]		Various	[illegible]	Full Button		1 T7	Square Flat	[illegible]	.49	Colored Plastic	1.1250	1.7500	1.750	Up to 6 Form C 5A @ 125 VAC	*$18.00 Per Station	Sectional Bezels Avail.
	Capco	[illegible]				Various	[illegible]			T7 Short Base	[illegible]	[illegible]	[illegible]	Colored Plastic	[illegible]	[illegible]	[illegible]	Various Leaf 3A @ 110 VAC		
		[illegible]				Various	[illegible]	Full Button		1 T 1 3/4 Mid. Flg.	Round Flat	[illegible] Dia	[illegible]	Colored Plastic	[illegible]	[illegible]	[illegible]	Various Leaf 3A @ 110 VAC		
		[illegible]	[illegible]			Various	1	Full Button		1 T 1 3/4 Mid. Flg.	Round Flat	[illegible] Dia	[illegible]	Colored Plastic	[illegible]	[illegible]	[illegible]	Various Leaf 3A @ 110 VAC		Turn to Release.
		PLS	[illegible]		Alternate	None	[illegible]			1 T7 Short Base	Rect Flat	[illegible]	[illegible]	Colored Plastic	[illegible]	7	[illegible]	Various Leaf 3A @ 110 VAC		
		PLS [illegible]	[illegible]		Alternate	None		Full Button		1 T 1 3/4 Mig. Flg.	Round Flat	[illegible] Dia	[illegible]	Colored Plastic	1	[illegible]	4	Various Leaf 3A @ 110 VAC		
		PLS [illegible]	[illegible]		Alternate	None		Full Button		1 T 1 3/4 Mig. Flg.	Round Flat	[illegible] Dia	[illegible]	Colored Plastic	[illegible]	[illegible]	[illegible]	Various Leaf 3A @ 110 VAC		
		[illegible]	[illegible]		Alternate	None		Full Button		1 T 1 3/4 Mig. Flg.	Round Flat	[illegible] Dia	[illegible]	Colored Plastic	1	[illegible]	[illegible]	Various Leaf 3A @ 110 VAC		
		[illegible]	[illegible]		Momentary	None	[illegible]	Full Button		1 T7 Short Base	Round Flat	5/8 Dia	[illegible]	Colored Plastic	[illegible]	1	[illegible]	Various Leaf 3A @ 110 VAC		Push-Turn Lock Feature Avail.
		MPB	[illegible]		Momentary	None		Full Button		T 1 3/4 Min. Bez.	Round Concave	5/8 Dia	[illegible]	Colored Plastic	[illegible]	1	[illegible]	Various Leaf 3A @ 110 VAC		
Switch Lite	Control Switch	[illegible]			Push Pull Snap Action	None	1	Full Button		1 T 1 3/4 Mig. Flg.	Round Concave	[illegible] Dia	[illegible]	Colored Plastic	[illegible]	Dia	[illegible]	SPST 10A @ 28 VDC	[illegible]	Bevel Flange, Alternate Buttons and Actions Avail.
Switch Lite		[illegible]			Push-Pull Snap Action	None	[illegible]	Full Button		1 T 1 3/4 Mig. Flg.	Round Concave	[illegible] Dia	[illegible]	Colored Plastic	[illegible]	[illegible]	[illegible]	DPDT 10A @ 28 VDC		Bevel Flange, Alternate Buttons and Actions Avail.
Switch Lite		[illegible]			Momentary Snap Action	None	[illegible]	Full Button		1 T 1 3/4 Mig. Flg.	Round Concave	[illegible] Dia	[illegible]	Colored Plastic	[illegible]	Dia	[illegible]	DPDT 10A @ 28 VDC		Bevel Flange, Alternate Buttons and Actions Avail.
Switch Lite		[illegible]	[illegible]	[illegible]	Alternate	None	[illegible]	Full Button		1 T 1 3/4 Mig. Flg.	Round Concave	[illegible] Dia	[illegible]	Colored Plastic	[illegible]	Dia	[illegible]	DPDT 10A @ 28 VDC		Bevel Flange, Alternate Buttons and Actions Avail.
Switch Lite		[illegible]			Momentary Snap Action	None	[illegible]	Full Button		1 T 1 3/4 Mig. Flg.	Round Concave	[illegible] Dia	[illegible]	Colored Plastic	[illegible]	[illegible]	[illegible]	DPDT 10A @ 28 VDC		Bevel Flange, Alternate Buttons and Actions Avail.
Switch Lite		[illegible]			Momentary Snap Action	None	[illegible]	Full Button		1 T 1 3/4 Mig. Flg.	Round Concave	[illegible] Dia	[illegible]	Colored Plastic	[illegible]	[illegible]	[illegible]	SPDT 10A @ 28 VDC	$13.00	Bevel Flange, Alternate Buttons and Actions Avail.
[illegible]		[illegible]	[illegible]	[illegible]	Alternate	None	1PC	Full Button		1 T 1 3/4 Mig. Flg.	Round Flat	[illegible] Dia	[illegible]	Translucent White Acrylic	1.25	[illegible]	[illegible]	DPDT 5A @ 125 VAC	$15.50	Colored Screens Avail.
[illegible]		[illegible]	[illegible]	[illegible]	Momentary Positive Feel	None	1PC	Full Button		1 T 1 3/4 Mig. Flg.	Round Flat	[illegible] Dia	[illegible]	Clear Acrylic	1.25	1.0	[illegible]	DPDT 5A @ 125 VAC	$14.00	
Tec Lite		[illegible]	[illegible]		Momentary Positive Feel	None	1	Full Button		2 T 1 3/4 Mig. Flg.	Rect Flat	[illegible]	1.0	Colored Plastic	[illegible]	1.00	[illegible]	DPDT 5A @ 125 VAC	$10.00	Clear Anodized Barriers Avail.
Tec Lite		[illegible]	[illegible]		Alternate	None	1	Full Button		2 T 1 3/4 Mig. Flg.	Rect Flat	[illegible]	1.0	Colored Plastic	[illegible]	1.00	[illegible]	DPDT 5A @ 125 VAC	$12.50	
Tec Lite		[illegible]	[illegible]		Momentary	None	1	Full Button		2 T 1 3/4 Mig. Flg.	Rect Flat	[illegible]	1.0	Colored Plastic	[illegible]	1.00	2	DPDT 5A @ 125 VAC	$10.00	
[illegible]		[illegible]	[illegible]	[illegible]	Momentary Positive Feel	None	1PC	Full Button		3 T 1 3/4 Mig. Flg.	Round Flat	1.0 Dia.	[illegible]	Translucent White Acrylic	[illegible]	1.375	[illegible]	DPDT 5A @ 125 VAC	$25.00	Colored Screens Avail.

* Per Station

Type Code: 1. Opaque Letters, Lighted Background; 2. Illuminated Letters, Opaque Background; 3. Same as 1 but Legend Invisible Until Illuminated; 4. Same as 2 but Legend Invisible Until Illuminated; PC - Projection Color

ILLUMINATED PUSHBUTTONS

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	LEGEND		[illegible] (FT-L)	[illegible]	BUTTON HEAD				PANEL [illegible]			ELECTRICAL [illegible]	PRICE	[illegible]
							TYPE	AREA			STYLE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	Control Switch	C30-00[illegible] -36	Pt Total 1/8	[illegible]	Alternate	None	1pc	Full Button		T 1 3/4 Mig Flg.	Round Flat	1.00 Dia.	25/32	Translucent White Acrylic	1 13/16	1.375	1 19/32	DPDT 5A@125 VAC	$26.30	
[illegible]		C 40-	3/16		Alternate	None	1pc	Full Button		T 1 3/4 Mig Flg	Square Flat	.875 x .875	7/32	Translucent White Acrylic	1.750	.875	1 09/64	DPDT 5A@125VAC	$25.00	Flange Mount
[illegible]		C 46-	3/16		Momentary Positive Feel	None	1pc	Full Button		T 1 3/4 Mig Flg	Square Flat	.875 x .875	7/32	Translucent White Acrylic	1 9/16	.875	1 29/32	DPDT 5A@125VAC	$26.10	Barrier Mount
[illegible]		[illegible]		[illegible]	Momentary	None	1pc	9/16 x 1.06		T 1 3/4 Mig Flg.	Rect Flat	[illegible] x 1.06	5/64	Translucent White Acrylic	1.20	[illegible]	2 17/32	DPDT 5A@125VAC	~$15.00	Black Flange
[illegible]		[illegible]		[illegible]	Alternate	None	1pc	9/16 x 1.06		T 1 3/4 Mig Flg	Rect Flat	[illegible] x 1.50	5/64	Translucent White Acrylic	1.20	[illegible]	2 5/8	DPDT 5A@125VAC	~$16.50	Black Flange
		[illegible]	1/8	[illegible]		Interlock Lockout	1	Full Button		T 1 3/4 Mig Flg.	Square Flat	1/2 x 1/2	[illegible]	Colored Plastic	[illegible]	2	[illegible]	DPDT		4 Button Unit 1/4 in. Spacing
	Cutler Hammer	[illegible]			Momentary Positive Feel	None	1	[illegible]			Rect Flat	9/16 x 11/16	15/32	White Plastic	[illegible]	11/16	[illegible]	SPST 5A@125VAC		Black Rim Around Legend Plate
		[illegible]	3/8		Alternate	None	1	61/64 x 1 5/16		T2 Short Base	Horiz. Bars	1/4 x 1.135	1/2	Gloss Black Plastic	[illegible]	[illegible]	1 15/32	DPDT 5A@125VAC	$14.20	Two Push Bars, One On One Off, Legend Between Push Bars
		[illegible]	[illegible]		Momentary Positive Fee.	None		61/64 x 1 5/16		T2 Short Base	Horiz. Bars	[illegible]	1/2	Gloss Black Plastic	[illegible]	[illegible]	1 15/32	DPDT 5A@125VAC	[illegible]	One Push Bar Above Legend
	[illegible]	[illegible]	1/32	16 oz	Momentary Snap Action	None	1pc	Full Button		[illegible]	Square Flat	1 x 1	.500	Translucent Colored Plastic	[illegible]	Dia	1.76	DPDT 5A@115VAC		Other Buttons Avail.
						None														
	General Control	[illegible]				Various	1	Full Button		T 1 3/4 Mig Flg	Round Flat	9/16 Dia	15/16	Clear Frosted Lucite	[illegible]	15/16	[illegible]	Various Load 1A@125VAC	~$7.25 Per Button	
	[illegible]	[illegible]	[illegible]	16 oz	Momentary	None	1	Full Button		GE 1764	Round Flat	[illegible] Dia.	[illegible]	Colored Plastic	[illegible]	Dia	1.40	SPST 1A@115VAC	[illegible]	
	[illegible]	[illegible]	.350	40 oz	Momentary Snap Action	None	1pc	Full Button		T 1 3/4 Mig Flg	Round	750 Dia.	[illegible]	Colored Plastic	15/16	[illegible]	1 29/32	DPDT 5A@115VAC		2-4 Poles Avail. Turn-to-Lock Feature Avail.
		[illegible]		[illegible]	Momentary	None	1pc	Full Button		T 1 3/4 Mig Flg	Round	750 Dia	.50	Colored Plastic	15/16	.790	1 9/16	DPDT 5A@115VAC		
		[illegible]	Total [illegible] 1/16 Detent	[illegible]	Alternate With Detent	[illegible]	1pc	Full Button		T 1 3/4 Mig. Flg	Round	750 Dia	[illegible]	Colored Plastic	15/16	.790	2 27/64	DPDT 5A@115VAC		Alt. Action Without Detent Avail. [illegible]
		[illegible]	.100	Actuate [illegible] Release [illegible]	Push-Pull	None	1pc	Full Button		T 1 3/4 Mig Flg	Round	750 Dia.	[illegible]	Colored Plastic	[illegible]	13/16	2.00	DPDT 5A@115VAC		
		[illegible]	[illegible]	[illegible]	Momentary Snap Action	None	1pc	1/2 Dia		T 1 3/4 Mig Flg	Round	5/8 Dia	[illegible]		25/32	41/64	[illegible]	DPDT 5A@115VAC		Incl. Shutter Dimmer Alt. Action Version [illegible]
		[illegible]	.125	[illegible]	Momentary Snap Action	None	1pc	Full Button		T 1 3/4 Mig Flg	Square	1.07 x 1.07	[illegible]		1.20	1.20	[illegible]	4 PDT		Lamps Wired 3 sets of 2 Solenoid Hold Version [illegible]
		[illegible]	.125	[illegible]	Alternate	None	1pc	Full Button		T 1 3/4 Mig. Flg.	Square	1.07 x 1.07	[illegible]		[illegible]	[illegible]	[illegible]	4 PDT		Lamps Wired 2 Sets of 2 Incl. Black Bezel
	[illegible]	[illegible]	.25	16 oz	Momentary or Alt. Avail.	Various Incl [illegible]	[illegible]	Full Button	[illegible] with 2 lamp available [illegible]	T 1 3/4 Mig Flg.	Rect Flat				[illegible]	[illegible]	[illegible]	DPDT 7A@28VDC		Button Housing Black, Solenoid Release Avail.
		[illegible]	[illegible]	40 oz	Momentary or Alt. Avail.	None	1pc	Full Button			Round Flat		.31		1.50	Dia		DPDT 5A@250VAC		Black Dress Cap
		[illegible]	[illegible]	40 oz		None	1pc	Full Button			Round Flat	[illegible] Dia	[illegible]					DPDT 5A@250VAC		Black Dress Cap

Type code see sheet 1

* Per Button

ILLUMINATED PUSHBUTTONS

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Legend		[illegible]	[illegible]	Button (Lens)				[illegible]			[illegible]	[illegible]	[illegible]
							Type	Area			Style	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Momentary	None	Pr. Stop	3/4 Dia	27 with one 180 lamp	[illegible] Mtg Flg	Rect Flat	[illegible]	.24	Flat Black Rim	2.00	1.00	1.76	DPDT 5A @ 250 VAC	$95.00	Viewing screen recessed in push button.
[illegible]		[illegible]	[illegible]	[illegible]	Alternate	None	Pr. Stop	3/4 Dia	27 with one 120 lamp	[illegible] Mtg Flg	Rect Flat	[illegible]	.24	Flat Black Rim	2.00	1.00	1.76	DPDT 5A @ 250 VAC	$61.00	Viewing screen recessed in push button.
Console Switch	JAY-EL	[illegible]	[illegible]	[illegible]	Momentary	None	[illegible]	[illegible]		[illegible] Mtg Flg	Rect Flat		.10	Matte Black Anod. Rim	[illegible]	1.00	[illegible]	2 PDT 5A @ 125 VAC	$25.00	Lens recessed in button barriers available.
Console Switch		[illegible]	[illegible]	[illegible]	Alternate	None	[illegible]	[illegible]		[illegible] Mtg Flg	Rect Flat		.10	Matte Black Anod. Rim	[illegible]	[illegible]	[illegible]	2 PDT 5A @ 125 VAC	$20.00	Matrix mountable.
Console Switch		Series [illegible]	[illegible]	[illegible]	Momentary or Alt. Action	None	[illegible]	[illegible]		[illegible] Mtg Flg	Rect Flat		.25	Matte Black Anod. Rim	.75	1.25	1.56	1 to 4 PDT 7A @ 250 VAC	$22.50	Front flange.
Console Switch		Series [illegible]	[illegible]	[illegible]	Momentary or Alt. Action	None	[illegible]	[illegible]		[illegible] Mtg Flg	Square Flat	[illegible]	.10	Matte Black Anod. Rim	[illegible]	1.00	2.70	1 to 4 PDT 10A @ 250 VAC		Lamps wired in pairs round or square lens.
[illegible] Switch		[illegible]	[illegible]	[illegible]	Momentary	None	[illegible]	[illegible]		[illegible] Mtg Flg	Rect Flat			Matte Black Anod. Rim	[illegible]	[illegible]	[illegible]	2 PDT 10A @ 250 VAC		Two lamp module available from flange.
[illegible] Switch		[illegible]	[illegible]	[illegible]	Momentary	None	[illegible]	[illegible]		[illegible] Mtg Flg	Rect Flat			Matte Black Anod. Rim	[illegible]	[illegible]	[illegible]	4 PDT 10A @ 250 VAC		
[illegible]		[illegible]	[illegible]	[illegible]	Momentary	None	1	[illegible]		[illegible] Mtg Flg	Square Flat	[illegible]	[illegible]	White Lens Black Rim	.75	.75	[illegible]	DPDT 7A @ 250 VAC	$19.00	Other lens arrangements avail., grooved button edge
[illegible]		[illegible]	[illegible]	[illegible]	Momentary	None	1 pc	[illegible]		[illegible] Mtg Flg	Square Flat	[illegible]	.37	White Lens Black Rim	.75	.75	[illegible]	DPDT DB 10A @ 250 VAC		
[illegible]		[illegible]	[illegible]	[illegible]	Magnetic Hold	None	1 pc	[illegible]		[illegible] Mtg Flg	Square Flat	[illegible]	[illegible]	White Lens Black Rim	.75	.75	2.37	4 PDT 7A @ 250 VAC	$29.00	
[illegible]		[illegible]	[illegible]	[illegible]	Alternate	None	1 pc	[illegible]		[illegible] Mtg Flg	Square Flat	[illegible]	.37	White Lens Black Rim	.75	Dia	[illegible]	DPDT 7A @ 250 VAC	$21.00	
	[illegible]	[illegible]	[illegible]		Momentary	None	1	Full Button		[illegible]	Various			Colored Plastic	[illegible]	Dia.	[illegible]	SPST		Knurled nut.
		[illegible]			Momentary Snap Action	None		Full Button		[illegible]	Various			Colored Plastic	11/16	1	[illegible]	DPDT		
		[illegible]			Alternate	None		Full Button		[illegible]	Various			Colored Plastic	29/32	13/16	[illegible]	DPDT		
		[illegible]			Alternate	None	Various	[illegible]		[illegible]	Double Flat	[illegible] sq	[illegible]	Non-Reflect. Plastic	[illegible]*	[illegible]*	[illegible]	SPDT		Matrix mountable, Mom. action & two & four lamp units available.
		[illegible]			Momentary Snap Action	None	1	Full Button		[illegible] Mtg Flg	Various			Colored Plastic	[illegible]	Dia.	[illegible]	DPDT		Knurled nut.
		[illegible]			Momentary Snap Action	None	1	Full Button		[illegible]	Various			Colored Plastic	13/16	[illegible]	[illegible]	DPDT		
		[illegible]			Alternate	None	1	Full Button		[illegible]	Various			Colored Plastic	13/16	[illegible]	[illegible]	DPDT		
		[illegible]			4 Step Sequence	None	1	Full Button		[illegible]	Various			Colored Plastic	13/16	[illegible]	[illegible]	DPDT		
		[illegible]			Momentary Snap Action	None	1	Full Button		[illegible]	Various			Colored Plastic	.50	[illegible]	[illegible]	SPDT		Parallel lamps.
		[illegible]			Momentary Snap Action	None	1	Full Button		[illegible] Mtd. Flg	Various			Colored Plastic	5/8	[illegible]	2.25	SPDT		Parallel lamps
		[illegible]			Alternate	None	Various	[illegible]		[illegible] Mtd. Flg	Rect Flat	[illegible]	[illegible]	Non-Reflect. Plastic	[illegible]	[illegible]	[illegible]	DPDT		Matrix mountable, Mom. action & two & six lamp units available.
		[illegible]	[illegible]		Mom. Snap Action or Alternate	None	1 pc	[illegible]		[illegible] Mtg. Flg	Rect Flat	[illegible]	[illegible]	White Plastic	[illegible]	1.200	[illegible]	DPDT		Short & long barriers available.
		[illegible]	[illegible]			Interlock & Lockout	1	Full Button		[illegible] Mtg. Flg	Various			Colored Plastic	[illegible]*	[illegible]	1.00	[illegible]		Custom interlocked assemblies available.

Type Code See Sheet 1

* Per Station

ILLUMINATED PUSHBUTTONS

TRADE NAME	MFG	MODEL NUMBER	DISPLACEMENT (IN)	OPERATING FORCE	OPERATING ACTION	INTERLOCK	LEGEND TYPE	LEGEND AREA	LUMINANCE (FT-L)	LAMP NUMBER TYPE	BUTTON CAPS STYLE	SIZE (IN)	HEIGHT (IN)	FINISH	PANEL DIMENSIONS LENGTH (IN)	WIDTH (IN)	DEPTH (IN)	ELECTRICAL CONFIGURATION	PRICE	REMARKS OR SPECIAL FEATURES
	[illegible]	Series 51	[illegible]	Min. [illegible] 3 lb [illegible]	Mom. Snap Action or Alternate	None	1	Full Button		Mag. [illegible]	Square or Round Flat	7/8 Sq. or Dia.	~9/16	Colored Plastic	25/32	63/64	~1 1/2	DPDT 10A @ 250 VAC		
		Series 56	[illegible]	[illegible]	Mom. Snap Action or Alternate	None	1 PC	Full Button		T-1 3/4 Mag. Flg.	Square Flat	7/8 x 7/8	~17/16	Colored Plastic	.875	.875	2.90	DPDT 10A @ 250 VAC	~$15.00	Barriers Avail.
	[illegible]	[illegible]	1/8	1 lb	Momentary	None	1	Full Button		T-1 3/4 Mag. Flg.	Square Flat	3/4 x 3/4	3/8	Colored Plastic	7/8	7/8	2 1/4	4PDT & 4PST 3A @ 28 VDC	$ 9.00	
		[illegible]	1/8	2 1/2 lb	Momentary	None	1	Full Button		T-1 3/4 Mag. Flg	Square Flat	3/4 x 3/4	3/8	Colored Plastic	7/8	7/8	2 17/32	4 PDT 3A @ 28 VDC	$ 7.50	
		[illegible]	1/8	2 1/2 lb	Momentary	None	1	Full Button		T-1 3/4 Mag. Flg	Square Flat	3/4 x 3/4	3/8	Colored Plastic	7/8	7/8	2 21/32	4 PDT 3A @ 28 VDC	$20.00	
		[illegible]	1/8	~1 lb	Alternate	None	1	Full Button		T-1 3/4	Square Flat	3/4 x 3/4	3/8	Colored Plastic	7/8	7/8	3 11/32	4 PDT 3A @ 28 VDC	$12.25	
		[illegible]	1/8	2 1/2 lb	Momentary	None	1	Full Button		T-1 3/4	Round Flat	1.093 Dia.	3/8	Colored Plastic	1 3/8	1 3/8	2 17/32	4 PDT 3A @ 28 VDC	$18.00	
		[illegible]	1/8	2 1/2 lb Center 3 lb End	Momentary	None	1	Full Button		T-1 3/4	Rect. Flat	[illegible]	3/8	Colored Plastic	1 3/4	1 3/4	2 5/16	4 PDT 3A @ 28 VDC	$23.00	
		[illegible]	1/8	1 lb		Various	1	Full Button		[illegible]	Rect. Flat	3/4 x 3/4	1/8	Colored Plastic	7/64	7/64	[illegible]	Optional		
	Micro	SW[illegible]	[illegible]	[illegible]	Momentary Snap Action	None	1	Full Button	Red 60 White	[illegible]	Round Concave	31/32 Dia.	1 3/16	Colored Plastic	1 13/32	Dia.	3 1/16	SPDT DB 10A @ 115 VAC		
		SW[illegible]	[illegible]	[illegible]	Momentary	None	1	Full Button	Red 100 White	[illegible]	Round Flat	3/4 Dia.	3/4	Colored Plastic	7/8	Dia.	1 1/2	SPDT 3A @ 28 VDC		
		SW[illegible]	[illegible]	[illegible]	Momentary	None	1	Full Button	Red 55 White 150	[illegible]	Round Flat	1/2 Dia.	9/16	Colored Plastic	5/8	Dia.	1	SPDT DB 3A @ 28 VDC		
		SW[illegible]	[illegible]	[illegible]	Momentary	None	1	Full Button	Red 55 White 150	[illegible]	Round Flat	5/8 Dia.	5/8	Colored Plastic	3/4	Dia.	1 1/2	SPDT DB 2A @ 110 VAC		
		[illegible]	156	[illegible]	Momentary	None	1	Full Button	Red 55 White 156	[illegible]	Round Flat	9/16 Dia.	7/32	Colored Plastic	25/32	Dia.	1 7/8	SPST DB 2A @ 110 VAC		Rect. Button Avail.
		[illegible]	[illegible]	[illegible]	Push Pull	None	1	Full Button	Red 61 White 130	[illegible]	Round Concave	5/8 Dia.	1 1/8	Colored Plastic	1 1/8	Dia.	1 7/8	SPST DB		Incl. Momentary Contact Beveled Flange
		[illegible]		[illegible]	Momentary	None	Yes	[illegible]	Red 69 White 200	[illegible]	Rect. Flat	7/8 x 1 9/16	1/8	Colored Plastic	1 13/32	2 1/32	2 29/32	DPDT DB 10 A @ 250 VAC		Matrix Mountable 4 PDT Avail.
		[illegible]	[illegible]	[illegible]	Alternate	None	Yes	[illegible]	Red 69 White 200	[illegible]	Rect. Flat	7/8 x 1 9/16	1/8	Colored Plastic	1 13/32	2 1/32	2 29/32	DPDT DB 10A @ 250 VAC		Matrix Mountable 4 PDT Avail.
		[illegible]	[illegible]	[illegible]	Momentary Snap Action	None	Yes	[illegible]	Red White 300	[illegible]	Rect. Flat	7/8 x 1 9/16	1/8	Colored Plastic	1 7/32	2 1/8	1 7/16	SPST		Mode. SW200
		[illegible]	100	[illegible]	Momentary Snap Action				Red 61 White 1[illegible]	[illegible]										Divided Legend
		[illegible]	[illegible]	[illegible]	Alternate				Red 66 White 125	[illegible]										Divided Legend
	Master Specialties	Series 15 A[illegible]	[illegible]	[illegible]	Alternate	None	1 PC	[illegible]	Red 78 White 115	T-1 3/4	Rect. Flat	11/16 x 1	~3/32	Colored Plastic	.960	1.200	3.10	DPDT 5A @ 250 VAC	~$12.00	Clear or Black Bar Barriers Avail.
		Series 15M	[illegible]	[illegible]	Momentary Snap Action	None	1 PC	[illegible]	Red 78 White 115	T-1 3/4	Rect. Flat	11/16 x 1	~3/32	Colored Plastic	.960	1.205	3.10	DPDT 5A @ 250 VAC	~$10.00	Clear or Black Bar Barriers Avail.
		Series 20 A[illegible]	[illegible]	[illegible]	Alternate	None	1 PC	[illegible]	Red 61 White 176	T-1 3/4	Rect. Flat	~7/8 x 1 1/8	1/8	White Plastic	1.515	1.015	4 3/8	DPDT 5A @ 250 VAC	~$39.13	
		Series 20 M	[illegible]	[illegible]	Momentary Snap Action	None	1 PC	[illegible]	Red 61 White 1[illegible]0	T-1 3/4	Rect. Flat	[illegible]	1/8	White Plastic	1.515	1.015	4 1/8	DPDT 5A @ 250 VAC	~$37.73	

Type Code See Sheet 1

* Per Station

ILLUMINATED PUSHBUTTONS

Trade Name	Mfr	Model Number	Displacement (in)	Operating Force	Switching Action	Interlocking	Legend Type	Legend Area	Luminance (FT L)	Lamp Number Type	Button (Lens) Style	Button (Lens) Size (in.)	Button (Lens) Height (in.)	Button (Lens) Finish	Panel Dimensions Length (in.)	Panel Dimensions Width (in.)	Panel Dimensions Depth (in.)	Electrical Configuration	Price	Remarks or Special Features
	Micro Sw	Series [illegible]	.16	2 lb	Momentary (Mag. Hold)	None				[illegible]	Square				1 1/16	1 1/16	1 3/4	6 PDT 7A @ 115 VAC	$35 to $45	Meets MIL Spec 2696*
	M. [illegible] Brown	[illegible] ID 16	.16 .25	A 50-67 oz Rel 46-62 oz	Alternate	None	1pc	Full Button	Red 24 White .65	T 1 3/4 (327)	Rect Flat	1.00 x .95	.20	Colored Plastic	1.62	1.0	3.15	DPDT 5A @125 VAC	$9.70	Barriers Required Truncated pyramid screens avail.
		[illegible] 2D 2	.12 - .125	32-64 oz	Momentary Snap Action	None	1pc	Full Button	Red 26 White 195	T 1 3/4 (327)	Rect Flat	1.00 x .85	.28	Colored Plastic	1.62	1.0	3.55	DPDT 5A @ 125 VAC	$8.65	Flange mount Colored rim screens available
		[illegible] T	.145	20 oz	Momentary	None	1	Full Button	Button val Red 6 White 9.0	T 1 [illegible]	Rect Flat	.700 x .700	.265	Colored Plastic	.990	.612	1.04	DPDT	$15.95	
		[illegible] T	Total .195 Detent .100	Act. 20 oz Rel. 20 oz	Alternate with Detent	None	1	Full Button	Button val Red 9.2 White 15	T 1 [illegible]	Rect Flat	.700 x .700	.265	Colored Plastic	.990	.612	1 [illegible]	DPDT	$15.35	
		[illegible] D 16	.16 .125	Act. 36-47 oz Rel. 46-67 oz	Alternate	None	1pc	Full Button	Red 26 White 194	T 1 3/4	Round Flat	[illegible] Dia	.27	Colored Plastic	1.26	Dia.	2.24	DPDT 5A @ 125 VAC	$9.66	Guard Ring available
		[illegible]	.11 .125	32-64 oz	Momentary Snap Action	None	1pc	Full Button	Red 26 White 194	T 1 3/4	Round Flat	[illegible] Dia	.27	Colored Plastic	1.26	Dia.	2.24	DPDT 5A @ 125 VAC	$7.95	Guard Ring available
		[illegible] T2	.155	24 oz	Momentary Snap Action	None	1	Full Button	Red 5 White 11	T 1 3/4 Mid Gov	Round Concave	[illegible] Dia.	.40	Colored Plastic	.70	.64	2.06	DPDT 5A @ 125 VAC	$8.75	Alternate buttons available
		[illegible] T2	.155	32 oz	Momentary Snap Action	None	1	Full Button	Red 5 White 8	T 1 3/4 Mid Gov	Square Flat	[illegible]	.40	Colored Plastic	.70	.64	1.97	DPDT 5A @ 125 VAC	$8.76	Alternate buttons available
		[illegible] T2	[illegible]	Push 20-35 oz Turn 4 oz	Momentary Snap Action	None	1	Full Button	Button in Red 16 White 22	T 1 3/4 Mid Gov	Round Concave	[illegible] Dia	.40	Colored Plastic	.70	.64	2.06	DPDT 5A @ 125 VAC	$10.20	Turn to lock in [illegible] Alternate buttons available
		[illegible] T	[illegible] Detent .155	32 oz	Alternate with Detent	None	1	Full Button		T 1 3/4 Mid Gov	[illegible] Flat	5/8 across flats	.64	Colored Plastic	.70	.64	2.06	DPDT 5A @ 125 VAC	$10.18	Alternate buttons available
		[illegible] T2	[illegible] .12	Act. 46-56 oz Rel. 36-42 oz	Alternate	None	1	Full Button	Red 11 White 66	T 1 3/4 Mid Gov	Round Flat	1/2 Dia	.65	Colored Plastic	.70	.64	2.20	DPDT 5A @ 125 VAC	$7.45	Alternate colors available
		[illegible] PB	[illegible]	12 oz	Momentary Snap Action	None	1pc	Full Button		T 1 3/4 Mid Flg	Round Flat	[illegible] Dia	.61	Colored Plastic	1.31	1.26	4.06	DPDT 5A @ 125 VAC		
	M. [illegible]	[illegible]			Alternate	None	1	Full Button		1/4 x [illegible]	Rect Concave	[illegible]	[illegible]	Colored Plastic	1 1/8	1 1/16	1 5/16	SPST 2A @ 115 VAC	$1.06	Incandescent lamp available
	[illegible]	Series [illegible]	[illegible]	[illegible]		Locked out	1	Full Button		T 1 3/4 Mid Flg	Round Concave	[illegible] Dia	.50	Colored Lucite	[illegible]*	[illegible]*	[illegible]	Various Leaf 5A @ 115 VAC	$5.00 Per Station	Other interlock options incl. matrix
		[illegible]		[illegible]		Various	1	Full Button		T 1 3/4 or T 2	Square Flat	[illegible]	[illegible]	Colored Lucite	[illegible]*	1 5/8	[illegible]	Various Leaf 5A @ 115 VAC	$4.56 Per Station	
		Series [illegible]	[illegible] Type W	[illegible] Type [illegible]	Momentary	None	1	Full Button		T 2	Round	[illegible] Dia	[illegible]/16	Clear Lucite	1 [illegible]/16	[illegible]	[illegible]/32	Various Leaf 5A @ 115 VAC	$3.35	Turn lock version $6.[illegible]
	Pendar	[illegible]	[illegible]		Momentary	Various (Optional)	1pc	Full Button		T 1 3/4	Various	[illegible]	[illegible]	Colored Plastic	3/4	Dia		DPDT 2A @ 125 VAC	$5.35	Alternate operating forces of 1 2, 1, 1 1 2 5 or 7 lb.
		[illegible]	[illegible]		Alternate	Various (Optional)		Full Button		T 1 3/4	Square Flat	[illegible]	9/16	Colored Plastic	3/4	Dia		DPDT 2A @ 125 VAC	$21.00	
		[illegible]	[illegible]		Alternate with Detent	Various (Optional)	1	Full Button		T 1 3/4	Square Flat	[illegible]	9/16	Colored Plastic	3/4	Dia		DPDT 2A @ 125 VAC	$22.[illegible]	
		[illegible]	[illegible]		Momentary Snap Action	Various (Optional)		Full Button		T 1 3/4	Square Flat	3/4 x 3/4	[illegible]	Colored Plastic	15/16	15/16		DPDT 2A @ 125 VAC	$11.00	Incl. Bezel, other shapes available
		[illegible]	[illegible]	60 oz	Momentary Snap Action	None		Full Button		T 1 3/4	Rect Flat	[illegible] x 3/4	[illegible]	Colored Plastic	[illegible]	1		DPDT 2A @ 125 VAC	$16.[illegible]	
		[illegible]	[illegible]	60 oz	Alternate	None		Full Button		T 1 3/4	Rect Flat	1 x 3/4	[illegible]	Colored Plastic	[illegible]	1		DPDT 2A @ 125 VAC	$24.65	
Keyboard Snap In		[illegible]	12 Total [illegible]	6 oz	Momentary	None	1	Full Button		1	Round Concave	1/2 Dia	1/4	Colored Plexiglas	[illegible]	[illegible]	11/32	3-DB 1/2 A @ 28 VDC		5/8 Dia. flanged & 1/2 Dia. flat top lens available in 6 colors

Type [illegible] see sheet 1

*Per Station

ILLUMINATED PUSHBUTTONS

[illegible]	[illegible]	[illegible]	[illegible] (IN.)	[illegible]	[illegible]	[illegible]	LEGEND		LUMINANCE (FT-L)	LAMP [illegible] TYPE	BUTTON (LENS)				[illegible]			ELECTRICAL [illegible]	[illegible]	[illegible]
							TYPE	AREA			STYLE	SIZE (IN.)	HEIGHT (IN.)	FINISH	LENGTH (IN.)	WIDTH (IN.)	DEPTH (IN.)			
	[illegible]	[illegible]	[illegible]		Push Pull	None	1	Full Button		1 3/4 Mfg. Flg	Round Concave	11/16 Dia.		[illegible] Plastic	.86	Dia.	13/16	5 P Special 5A @ 28 VDC		0.86 Dia. Flush Mnt
		[illegible]	.093	30 ± 2 oz	Momentary	Optional [illegible]	1	Full Button		1 T1 3/4 Mfg. Flg	Square Concave	5/8 x 5/8	.570	Ivory Plastic	.917	Dia.	1 3/32	6 PDT 1A @ 115 VAC		Round flat button avail.
		[illegible]	.100	[illegible]	[illegible] Solenoid Hold	None	1	Full Button		4 T1 3/4 Mfg. Flg	Rect Concave	.97 x 1.09	.562	Colored Plastic	1.075	1.210	2.563	4 PDT 5A @ 115 VAC		Barriers avail.
		[illegible]	[illegible]	25 oz	Momentary or Alternate	None	1	Full Button		1 T1 3/4 Mfg. Flg	Rect Flat	.75 x 1.00	.156	Colored Plastic	1.107	1.00	2 3/32	DPDT 5A @ 125 VAC		Barriers avail.
		[illegible]	.344	25 oz	Momentary	None	1	Full Button		2 T1 3/4 Mfg. Flg	Rect Flat	.70 x 1.00	5/32	Colored Plastic	1.106	1.06	2 1/2	DPDT 1A @ 115 VAC		Barriers avail.
		[illegible]	.0	16 oz	Momentary Push & Twist	None	1	Full Button		1 T1 3/4 Mfg. Flg	Round With [illegible]	1 1/8 Dia.	-3/4	Colored Plastic	1 5/8	1 5/8	1 3/32	4 PDT 1A @ 115 VAC		
	[illegible]	[illegible]			Alternate	None	[illegible]	Full Button		T1 3/4 Mfg. Flg	Rect Flat	.175 x 1.250	3/8		2.062	1.250	2.700	SPDT		Assembly of three units Diodes in lamp circuit
		[illegible]	[illegible]	32 oz	Momentary Snap Action	None	1 pc	1.00 Dia	White [illegible] with 2 lamps	4 T1 3/4 Mfg. Flg	Round Flat	~1 1/8 Dia.	.376		1.50	1.50	~0 1/8	DPDT 3A		Lamps wired in [illegible] sets of 2 Black housing, colored
		[illegible]	.19	25 oz	Alternate	None	1 pc	1.00 Dia	White [illegible] with 2 lamps	4 T1 3/4 Mfg. Flg.	Round Flat	~1.0 Dia	.126		1.56	1.56	~4 1 4	DPDT 3A		Lamp filters.
	[illegible]	[illegible]	.0			Various	1	11/16 Dia		1 6 volt Min. Scr	Round Recessed	1/2 Dia	7/8	Colored Plastic	5/8*	1 5/8	1 5/16	Various load 3A, 30C watts	~$8.50 per station	Rect. buttons avail.
		[illegible]	.0			Various	1 pc	Full Button		1 T1 3/4 Mfg. Flg	Square Concave	9/16 x 9/16	1 1/8	Colored Plastic	5/8*	1 5/8	1 5/16	Various load 3A, 30C watts	~$8.50 per station	
		[illegible]	.0		Momentary	None	1 pc	Full Button		1 T1 3/4 Mfg. Flg	Square Concave	9/16 x 9/16	1 1/4	Colored Plastic	1 1/8	5/8	2 7/8	Various Load 3A, 30C watts	$9.25	
		[illegible]	Travel 1.0 1.0 Detent		Alternate with Detent	None	1 pc	Full Button		1 T1 3/4 Mfg. Flg	Square Concave	9/16 x 9/16	1 1/4	Colored Plastic	1 1/8	5/8	2 7/8	Various Load 3A, 30C watts	$9.25	
	[illegible]					None	1	Full Button		1 T2	Round Flat	25/64 Dia.	~1/8	Colored Plastic	3/4	Dia	~2	DPDT 5A @ 250V		
	[illegible]	Binary Encoded				Interlock & Lockout		Full Button						Colored Plastic	10 1/16	15/16	1 3/32	6P 3A @ 120 VAC		10 Button array, binary encoded output
		Multiple [illegible]	.16	4 oz		Various [illegible]	1	Full Button		1 T2	Rect Flat		~7/8	Colored Plastic	.700	.625	1 7/8	Various 0.5A @ 115 VAC		
	TEC	TBL	.06	6 oz	Momentary	None	1	Full Button		1 Neon	Round Flat	.300 Dia	.30	Clear Plastic	9/16	Dia.	~2	SPST 100 MA	~$13.00	Incl. Transistor drive Black knurled nut
						None	1	~1/2 x ~1		2	Rect Flat	~5/8 x ~1 1/8	~9/16		~1 1/8	~13/16				
	[illegible]	[illegible]			Momentary	None	1	Full Button		1 TEL S B	Rect Flat		.20	Colored Plastic	1.62	.96	3.35	DPDT 5A @ 220 VAC	$8.75	Black Range
		[illegible]			Alternate	None	1	Full Button		1 TEL S B	Rect Flat		.20	Colored Plastic	1.62	.96	3.35	DPDT 5A @ 220 VAC	$9.00	Black Range
					Alternate	None	1	Full Button		1 TEL S B	Rect Flat	11/16 x 1 1/2	.2C	Colored Plastic	1 7/8	15/16	1 3/8	SPDT		Black Range

Type Code See Sheet 1

* Per Station

ILLUMINATED PUSHBUTTONS

TRADE NAME	MFG	MODEL NUMBER	DISPLACEMENT (IN)	OPERATING FORCE	SWITCHING ACTION	INTERLOCK	LEGEND TYPE	LEGEND AREA	LUMINANCE (FT-L)	LAMPS NUMBER TYPE	BUTTON (LENS) STYLE	BUTTON (LENS) SIZE (IN)	BUTTON (LENS) HEIGHT (IN)	BUTTON (LENS) FINISH	PANEL DIMENSIONS LENGTH (IN)	PANEL DIMENSIONS WIDTH (IN)	PANEL DIMENSIONS DEPTH (IN)	ELECTRICAL CONFIGURATION	PRICE	REMARKS OR SPECIAL FEATURES
	Dia[illegible]		[illegible]/4	2 lb	Momentary	None	1 or 2	Full Button		1 T1 3/4 Mig. Flg	Round or Sq. Flat	1/2 Sq. or Dia.	.430	Colored Plastic	5/8	Dia.	1 15/32	SPST 3A 125 VAC		Many button colors and dark ram avail.
Press Lite	Eao	PLCB 2AW	?/32		Alternate	None	1	Full Button		1 T1 3/4 Mig. Flg	Round Flat	11/32 Dia.	1/2	R, G, Y, Or W Nylon	9/16	Dia.	2	SPDT 2A @ 125 VAC		Other models in development
Press Lite	Eao	PLCB-15DW	?/32		Alternate	None	1	Full Button		1 T1 3/4 Mig. Flg	Round Flat	7/16 Dia.	5/8	R, G, Y, Or W Nylon	3/4	Dia.	2	SPDT 15A @ 125 VAC		

KEYBOARDS

MANUF.	MODEL NUMBER	GENERAL DESCRIPTION	CONFIGURATION	NUMBER OF KEYS	OPERATING FORCE	DISPLACEMENT (IN.)	KEY (BUTTON) STYLE	KEY (BUTTON) SIZE (IN.)	KEY (BUTTON) COLOR	INTERLOCK	OVERALL SIZE L (IN.)	OVERALL SIZE W (IN.)	OVERALL SIZE H (IN.)	SLOPE	COLOR	OUTPUT	APPROX PRICE	REMARKS OR SPECIAL FEATURES
Burroughs	410	Numeric	3 x 3 + 1 Add. Mach.	11	3 oz	1/8	Square (0 Bar)		Dark Blue		6 3/8	4 1/16	2 1/2		Dark Blue	SPDT Each Key	$ 145	Extra Keys on Top.
	63115	Numeric	3 x 3 + 3 Add. Mach.	16	3 oz	1/8	Square (0 Bar)		Black		6 1/2	5	2 1/16	13°	Beige	SPDT Each Key	$ 295	Extra Keys on Left.
Concord Control	Q Series	Numeric	3 x 3 + 1 Add. Mach.	10			Square Concave									Up to DPDT Each Key	$ 165	Zero Key in Bar.
	Q Series	Limited Alpha-Numeric	3 x 4 + 2	14			Square Concave									Up to DPDT Each Key	$ 195	
	Q Series	Limited Alpha-Numeric	4 x 5	20			Square Concave									Up to DPDT Each Key	$ 100	Q series is semi-custom, custom keyboards available.
Connecticut Technical		Numeric	3 x 3 + 2 Add. Mach.	13	5 oz Neg. Resis.	3/16				None			3	15°		Direct No Coding		Contains Buffer Store for 11 digits, also "Enter" & "Clear" Keys
		Alpha-Numeric	Typewriter		3 oz Linear	1/4				None			2 1/2	15°				
		Alpha-Numeric	Typewriter		4 oz Linear	1/4				Optional			4	15°		Coded 6 Bit		
Electrada	408 Datacom	Alpha-Numeric Entry & Edit	Typewriter Plus 4 x 5 - 2 and 4 x 6	54 Plus 22 and 24												Coded 5, 6, 7, or 8 bit		Includes CRT display & drum buffer store, photoelectric keys.
Friden	ACPT Add-Punch	Numeric Adding Machine	"Natural Way" 3 x 3 + 9	18	< 6 oz		Square or Rect.	1/2 sq						30°	TAN	Punched Tape 5, 6, 7, or 8 bit	$ 7450	Entry accumulator plus adding machine tape.
		Numeric	5 x 3 + 1	16						Lockout	6	6	3 1/2			Coded 4 to 8 bit		
	SFD Flexowriter	Alpha-Numeric	Typewriter	51			Square			Lockout	17 1/4	20	10		TAN	Coded	$ 2600	Tape punch & Reader
IBM	Model B	Alpha-Numeric	Typewriter		2 to 2 1/2 oz	3/16	Square Concave	17/32 sq		Lockout				11°				Max. rate 10.5 char/sec
	Selectric	Alpha-Numeric	Typewriter		2 to 3 oz except Num. 3 to 3 1/2 oz	3/16	Square Concave	17/32 sq		Lockout		17	10	11°				Max. rate 15.5 char/sec 465L version has O.F. of 6-8 oz.
	632 Keyboard	Numeric	3 x 3 + 1 Add. Mach	10	2 1/2 oz except Zero 3 to 3 1/2 oz	1/8	Square Concave	17/32 sq.		Lockout				15°				Inverted keyboard configuration available max. rate 15 to 18 char/sec.
	026 #1 Keyboard	Numeric	3 x 3 + 1 Inverted Add. Mach.															
	026 #3 Keyboard	Alpha-Numeric	Similar to Typewriter except Numerals															
IPC	EK-176	Numeric	3 x 3 + 1 + 5	15 Plus 2 Control	4.3 - 5.0 oz Neg. Res.	.24 ± .03			Brown	Lockout	7 1/2	7 3/4	4 3/8	15°	Brown	Coded 6-bit	$ 155	
		Alpha-Numeric	Typewriter															

KEYBOARDS

MANUF	MODEL NUMBER	GENERAL DESCRIPTION	CONFIGURATION	NUMBER OF KEYS	OPERATING FORCE	DISPLACEMENT (IN.)	KEY BUTTON STYLE	KEY BUTTON SIZE (IN.)	KEY BUTTON COLOR	INTER-LOCK	OVERALL SIZE L (IN.)	OVERALL SIZE W (IN.)	OVERALL SIZE H (IN.)	SLOPE	COLOR	OUTPUT	APPROX. PRICE	REMARKS OR SPECIAL FEATURES
INVAC	K-110	Numeric	3 x 3 + 1 + 5 Add. Mach.	15						Lockout	12 3/8	7 3/4	4 1/8			Coded 5, 6, 7, or 8 bit	$ 325	Photoelectric, up to 20 keys available.
	PR-144	Alpha-Numeric	Typewriter	44*	2 to 8 oz	5/32 - 5/16	Square	9/16 sq.		Lockout	12 3/8	12 5/8	5 1/2	15°		Coded 5, 6, 7, or 8 bit	$ 595	Photoelectric, no printing mechanism, max. rate 10-15 char./sec.
	TTR-200	Alpha-Numeric	Typewriter							Lockout						Coded IBM Selectric	$1200	IBM selectric modified with photoelectric encoding
Mossman	Series 7100	Numeric	3 x 3 + 1 Telephone	10			Round											Zero key elongated
Monroe	16 Key	Numeric	3 x 3 + 1 + 6 Add. Mach.	16													$ 485	Used with monrobot
Precision Specialities		Alpha-Numeric	Similar to Typewriter	45											Two Tone Grey	Coded EIA 8 bits	$ 200	Used with Friden Tape Punch
Royal McBee			Typewriter		2 to 4 oz	3/16								10° - 18°				
Smith-Corona		Alpha-Numeric	Typewriter	53	Variable 1 3/4 - 3 1/2 oz	0.2	Rect.	1/2 x 9/16	Tan	None						Sep. contacts for each key	$1000	
		Alpha-Numeric	Typewriter	53	Variable 1 3/4 - 3 1/2 oz	0.2	Rect.	1/2 x 9/16	Tan	Lockout						Coded		
	551 Electronic Data Printer	Alpha-Numeric	Similar to Typewriter	32 or 51	Variable 1 3/4 - 3 1/2 oz	0.2	Rect.	1/2 x 9/16	Tan	Lockout	26	16 1/2	8 1/2	15°	Grey	Coded 5, 6, 7, or 8 bit		Incl. high speed printer, also 17 mode switches.
Soroban	EC Computeriter	Alpha-Numeric	Typewriter	42* or 44*			Square									Coded up to 8 bits	$ 985	Modified IBM model B, max. rate 10 char/sec.
	FK-2 S Numeric	Numeric	6 x 3 + 4	22	~ 6 oz		Square		Optional	Lockout					Light Grey	Coded up to 8 bits	$ 340	
	FK-2 L Alpha-Numeric	Alpha Numeric	Similar to Typewriter	39	~ 6 oz		Square		Optional	Lockout					Light Grey	Coded up to 8 bits	$ 815	Up to 64 keys available.
Teletype	28	Alpha-Numeric	3 Row Communication	32*			Round		Grey Green		18 1/2	20 1/2	16	~ 25°	Optional	Coded 5 bit		Table model
	29	Alpha-Numeric	4 Row Similar to Typewriter	42*			Round				23 1/2	36	39			Coded 8 bits		Floor mounted send-receive set
Temco	Message Composer	Alpha-Numeric Enter & Edit	5 x 11 + 8	63			Square				21	32	40			Coded 5 bit		Incl. message storage and strobe light display.
Varilab	430 Punch	Numeric	3 x 4 + 2	14			Rect.				10	12	3	0°		Punched Cards		Portable card punch. Two arrangements of keys.

KEYBOARDS

SHEET 3 OF [illegible]

MANUF.	MODEL NUMBER	GENERAL DESCRIPTION	CONFIGURATION	NUMBER OF KEYS	OPERATING FORCE	DISPLACEMENT (IN.)	KEY (BUTTON)			INTER-LOCK	OVERALL SIZE			SLOPE	COLOR	OUTPUT	APPROX. PRICE	REMARKS OR SPECIAL FEATURES
							STYLE	SIZE (IN.)	COLOR		LENGTH (IN.)	HEIGHT (IN.)	WIDTH (IN.)					
Victor	12-031	Numeric	10 x 9 (no zero keys)	90			Square		Brown	Latching	15	10	8 1/4		Brown	SPDT Each Key		8 column unit available.
	12-032	Numeric	[illegible]	[illegible]			Square (0 bar)		Brown	Latching Code Keys	15	10	8 1/4			SPDT Each Key		Multiple columns of code keys available.
	12-003	Numeric	3 x 3 + 1 + 2	12			Round (0 bar)		Optional		3 1/2	3 1/2	1 1/2			SPDT Each Key		Portable

ROTARY SWITCHES

SHEET 1 OF 5

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		[illegible]			[illegible]	[illegible]	[illegible]
							LENGTH (IN.)	[illegible] (IN.)	[illegible] (IN.)	[illegible] (IN.)	LENGTH (IN.)	STYLE	[illegible]	[illegible] (IN.)			
	Centralab	Series 100	2 to 11	30° or 60°	1 to 3		1 17/32	15/16	2 1/4 Max	1/4 or 1/8	Optional	None			.17A @ 115 VAC		
		Series PA-600	4 to 11	30° or 60°	1 to 2		1 9/32	1 5/16	~1/8	1/4	Optional	None			25A @ 115 VAC		Adjustable stops available
		Series 2??	2 to 11	30°, 45°, 60°, 90° or 180°	1 to 6		1 7/8	1 5/8	~1 1/8	1/4	Optional	None			.25A @ 115 VAC		
		Series PA-690	10	20°	1 to 6		2 5/16	2 11/64	~1 1/2	1/4	Optional	None			25A @ 115 VAC		
		Series PA-675	24	15°	1 to 4		2 5/16	1 15/16	~1 1/2	1/4	Optional	None			25A @ 115 VAC		
		Series 400	2 to 12	30° or 60°	1 to 6		2 15/16	2	~ 9 Max	1/4	Optional	None			5A @ 115 VAC		
	Chicago Dynamics	RS-15	36	10°	1 to 12		1 5/8	1 1/8	2 7/8 for 4 wafer			Round Slotted Bar		~1" Dia.	125A @ 115VAC		Plug-in printed circuit wafers
		RS-40	30	10°	1 to 30		4 3/8	4	1 17/16 for 1 wafer			Round Pointer		~1 Dia.	125A @ 115VAC		Plug-in printed circuit wafers 12 & 10 Position wafer also avail.
		RS-C-21	100 Max.	36°	10		2	2	4 1/8			Multi-Rotation Dial			.125A @ 115VAC		Plug-in printed circuit wafers Single pole for Max. No. of Pos.
		RS-C-36	200 Max	20°	25		3	3	8 5/32			Multi-Rotation Dial			.125A @ 115 VAC		Plug-in printed circuit wafers Single pole for Max. No. of Pos.
		RS-C-60	400 Max	15°	26		4	4	11 5/16			Multi-Rotation Dial			.125A @ 115 VAC		Plug-in printed circuit wafers Single pole for Max. No. of Pos.
	[illegible]	CVB-11	2-12	11 1/4°	[illegible]		1 1/8	1 3/8	1 11/16	250	15/16	None			~2A @ 115 VAC		Adjustable stops
		CVB-36	2-12	36°	1		1 1/8	1 1/4	1 11/16	250	15/16	None			~2A @ 115 VAC		Adjustable stops
		Series 10	2-60	[illegible] 22 1/2, 15, 11 1/4 or 7 1/2	1 to 8		2 1/4	2 1/4	1 7/16 for 1 wafer	250	15/16	None			~2A @ 115 VAC		
Tape Key	[illegible]	PT-40	2	90°	NA		27/32	9/16	1 1/8	NA	NA	Screw Bar	Black Bakelite	7/16 Dia. x 5/8	2 Form C .A @ 110 VAC	$2.50	Cam operated leaf contacts.
	CTS	Series 212	12	30°			1 5/16	1 3/8		250	Optional	None			3/4A @ 125 VAC		
		Series 211	12	30°		25 to 05 oz.-in.	1 5/16	1 3/8		250	Optional	None					
	Daven	[illegible]-CB-12A	12	30°	1		1 5/8	1 3/4	1 7/16	250	9/16	None			1 Pole 2A @ 115 VAC		Adjustable stops
		[illegible]-CB-16A	16	22 1/2°	1		1 1/8	1 3/4	1 7/16	250	9/16	None			1 Pole 2A @ 115 VAC		Adjustable stops.
		[illegible]-PM-60	60	6°	1		2 19/16	2 19/16	1 7/16	250	15/16	None			1 Pole 2A @ 115 VAC		
		[illegible]-PB-30	30	12°	1		2 19/16	2 19/16	1 7/16	250	15/16	None			1 Pole 2A @ 115 VAC		
		[illegible]-DM-24	24	15°	1		2 1/4	2 1/4	1 9/16	250	15/16	None			6 Pole 2A @ 115 VAC		

ROTARY SWITCHES

SHEET 2 OF 3

TRADE NAME	MFG CODE	MODEL NUMBER	NUMBER OF POSITIONS	ANGULAR DISPLACEMENT	NUMBER OF DECKS	OPERATING FORCE	PANEL DIMENSIONS LENGTH (in)	PANEL DIMENSIONS WIDTH (in)	PANEL DIMENSIONS DEPTH (in)	SHAFT DIA (in)	SHAFT LENGTH (in)	KNOB CHARACTERISTICS STYLE	KNOB CHARACTERISTICS FINISH	KNOB CHARACTERISTICS SIZE (in)	ELECTRICAL RATING	APPROX PRICE	REMARKS OR SPECIAL FEATURES
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			5 Pole 2 A @ 115 VAC		
		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			6 Pole 2 A @ 115 VAC		
		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			6 Pole 2 A @ 115 VAC		
		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			6 Pole 2 A @ 115 VAC		
		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			5 Pole 2 A @ 115 VAC		
		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			4 Pole 2 A @ 115 VAC		
		[illegible]		[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			1 Pole 1 A @ 28 VDC		
	[illegible]	Type A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	AN3220-3 Powder	Matte Black	[illegible]	[illegible] A @ 125 VAC	$ 7.50	Add or subtract 1 lb-in. per deck
		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Optional	Powder	Gloss Black	[illegible]	[illegible] A @ 125 VAC	[illegible]	Add 1 lb-in. per deck
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Optional	Powder	Gloss Black	[illegible]	[illegible] A @ 125 VAC	$10.75	
		Type [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		Powder	Gloss Black	[illegible]	[illegible] @ 125 VAC	[illegible]	Add 1 lb-in. per deck
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			2 A @ 125 VAC	[illegible]	
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			[illegible] A @ 125 VAC	$12.50	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	None			1 A @ 115 VAC	[illegible]	Dial plate avail.
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	None			1 A @ 115 VAC	$ 7.55	
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	None			1 A @ 115 VAC	[illegible]	One position spring return.
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	Optional	None			[illegible] A @ 125 VAC		Spring return and stops avail
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Optional	None			[illegible] A @ 125 VAC		Spring return avail
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Optional	None			[illegible] A @ 125 VAC		Spring return avail.
		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	Optional	None			[illegible] A @ 125 VAC		Spring return avail.
		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	Optional	None			[illegible] A @ 125 VAC		
		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	Optional	None			[illegible] A @ 125 VAC		
		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	Optional	None			[illegible] A @ 125 VAC		

ROTARY SWITCHES

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		[illegible]			[illegible]	[illegible]	[illegible]
							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	STYLE	[illegible]	[illegible]			
	Industrial Timer	Series [illegible]	12	30°	1 to 12				1 Plus 1 Per Deck						10 A		Cam operated SPDT snap switches easily removable and programmable cams.
	[illegible] Inst.	711240[illegible]	12	30°	4	3 in.-lb	1 5/32	Dia	1.5	1/8	11/32	Round Pointer	Black Plastic		.2 A @ 115 VAC		
		60714120	5	30°	2	1.1-2 in.-lb	1 5/32	Dia	0.9	1/8	11/32	Round Pointer	Black Plastic		.2 A @ 115 VAC		Spring return.
	Janco	6-1000-1A24C	24	15°	1	1 to 3 in.-lb	2.0	Dia	1.0	.250	.375	None			5 A @ 115 VAC		
		6-1000-5A24C	24	15°	5	1 to 3 in.-lb	2.0	Dia	2.46	.250	.375	None			5 A @ 115 VAC		
		3-1000-1A16C	16	22 1/2°	1	1 to 3 in.-lb	1.5	Dia	1.1	.250	.37	None			5 A @ 115 VAC		
		3-3000-6A16C	16	22 1/2°	6	1 to 3 in.-lb	1.9	Dia	2.24	.250	.37	None			5 A @ 115 VAC		
		1000-6A10C	10	36°	6	1 to 3 in.-lb	1.00	Dia	1.90	.250	.37	None			5 A @ 115 VAC		
		1006-3A8C	8	45°	3	1 to 3 in.-lb	1.56	Dia	1.83	.250	.37	None			5 A @ 115 VAC		
		3-1906-2A6C	6	60°	2	1 to 3 in.-lb	1.33	Dia	1.70	.250	.37	None			5 A @ 115 VAC		
		1211	16	22 1/2°	5	8 in.-lb max	1 3/8	Dia	3 7/8			Pointer			6 A @ 28 VDC		Pull shaft to enter position 16.
		1244	5	72°	5	8 in.-lb max	2.125	Dia	3.5	.240	.701	None			10 A @ 28 VDC		360° rotation
		1200	10	36°	1	7 in.-lb max	2.375	Dia	1.5	.240	.701	None			6 A @ 115 VAC		
		1206	1	45°	5	8 in.-lb max	1 7/8	Dia	3	.240	1.2	None			10 Pole 5 A @ 125 VAC		
	JBT	711210	11	30°	1	22 in.-oz	1 1/16	Dia	.60	1/8	11/32	Round Pointer	Black Plastic		1 A @ 115 VAC	$4.95	
		711240	11	30°	4	30 in.-oz	1 1/16	Dia	1.474	1/8	11/32	Round Pointer	Black Plastic		1 A @ 115 VAC	$11.05	
		541020	10	30°	2	30 in.-oz	1 1/16	Dia	.910	1/8	11/32	Round Pointer	Black Plastic		4 Pole 1 A @ 115 VAC	$7.50	
		MB-16-4	16	22° 30'	4	75-95 in.-oz	2	Dia	1 5/8	1/4	3/8	Bar		1 1/4 in.	1 A @ 115 VAC	$6.40	Adjustable stop.
		MB-20-6	20	18°	6	55-77 in.-oz	2 23/32	Dia	2 3/16	1/4	3/8	Bar		2 in.	1 A @ 115 VAC	$9.40	Adjustable stop.
		MB-20-6	20	18°	6	40-60 in.-oz	2 5/8	Dia	2 1/8	1/4	7/16	Bar		2 in.	1 A @ 115 VAC	$8.60	
	Leeds Northrup	31-3-0-1	12	30°	1	15-20 in.-oz	2	Dia	1 5/8	1/4		Round Dial		2 1/2 in.	1 A @ 115 VAC	$16.50	Switch action adjustable by screw from no detent action to stiff operation.
		31-3-0-4	12	30°	4	15-20 in.-oz	2	Dia	3 11/16	1/4		Round Dial		2 1/2 in.	1 A @ 115 VAC	$60.50	Adjustable stops.

ROTARY SWITCHES

SHEET 4 OF 5

TRADE NAME	MFG CODE	MODEL NUMBER	NUMBER OF POSITIONS	ANGULAR DISPLACEMENT	NUMBER OF DECKS	OPERATING FORCE	PANEL DIMENSIONS LENGTH (IN.)	PANEL DIMENSIONS WIDTH (IN.)	PANEL DIMENSIONS DEPTH (IN.)	SHAFT DIA. (IN.)	SHAFT LENGTH (IN.)	KNOB CHARACTERISTICS STYLE	KNOB CHARACTERISTICS FINISH	KNOB CHARACTERISTICS SIZE (IN.)	ELECTRICAL RATING	APPROX. PRICE	REMARKS OR SPECIAL FEATURES
	Mallory	3241 L	12	30°	4		2 3/8	2 1/16	2 1/2	.249	2	None			4 Pole 4A @ 110 VAC		Adjustable stop
		RB30	2 to 12	30°, 60° or 90°		High	1 15/16	Dia		.249	Optional	None					
		RB36	2 to 12	30°		Low	1 15/16	Dia		.249	Optional	None					
	Moon	L Series	2 to 12	30°	1	2 to 6 in.-lb	1 31/64	Dia	11/32 + 27/64 per Deck	.25	1/2	None			1 Pole 5A	$15.22	Adjustable stop
		562202	12	30°	2	2 ± 1 in.-lb	1 5/16	Dia	1 21/64	.25	17/32	None			2 Pole 15A @ 28 VDC	$125.00	7° play in contact pos. 15° advance before contact moves to next pos.
		MJ901A7	8	45°	2	6 in.-lb	[illegible]	Dia	2 7/16	.25	17/32	None			2 Pole 5A @ 110 VAC	$66.75	
	Micro Switch	17AS0201	10	36°	4	10 ± 4 in.-oz	1.12	[illegible]	1.56	.125	.57	None			BCD Com 1A @ 30 VDC	$12.50	20 or 40 in-oz operating force also avail. Micro switch elements
		29A3	3	45°	5	45 ± 15 in.-oz	1.53	1.20	2.2	.25	.375	None			SPDT Com 5A @ 125 VAC	$31.50	Micro switch elements, up to 7 elements avail., push and fire action
	Micro Switch	8-RZ-12	15	24°	4	32 in.-oz	1 1/2	1 3/8	[illegible]	1/4	Optional	None			4P Com 5A @ 125 VAC	$12.90	Micro switch elements, up to 2K
	Oak	Series A	2 to 12	30° 36° 45°		Various	1 3/32	Dia		.25	Optional	None			0.5A @ 110 VAC		Spring return and adjustable stops avail.
		Series F	2 to 12	30° 45° 60° 90°		Various	1 1/8	Dia		.25	Optional	None			0.5A @ 110 VAC		Spring return, adjustable stop and push to turn avail.
		Series H	2 to 12	30°, 36° 45°, 60°		Various	1 7/8	Dia		.25	Optional	None			0.5A @ 110 VAC		Spring return, adjustable stop and push to turn avail.
		Series K	2 to 24	15°, 30°, 36°, 45°, 60°		Various	1 9/16	Dia		.25	Optional	None			0.5A @ 110 VAC		Spring return avail.
		Series L	2 to 10	30°, 60°		Various	2 1/8	Dia		.25	Optional	None			0.5A @ 110 VAC		
		Series MF	2 to 24	15°		Various	2 5/16	1 13/16		.25	Optional	None			0.5A @ 110 VAC		
		Series GF	16, 20	15.7° 12.85°			2 1/2	1 13/16		.25	Optional	None			0.5A @ 110 VAC		
		Series RK	20	18°			1 13/16	Dia		.25	Optional	None			0.5A @ 110 VAC		
			12	30			1 1/2	Dia									
	Pointon	PR	up to 25	17 Ext.	up to 6		2 1/8	1 5/8	1 9/64 + 3/8 per Deck	.249	Various	Skirted Hex			0.5A @ 250 VAC		Adjustable stops

ROTARY SWITCHES

SHEET 5 OF 5

TRADE NAME	MFG CODE	MODEL NUMBER	NUMBER OF POSITIONS	ANGULAR DISPLACEMENT	NUMBER OF DECKS	OPERATING FORCE	PANEL DIMENSIONS LENGTH (in.)	PANEL DIMENSIONS WIDTH (in.)	PANEL DIMENSIONS DEPTH (in.)	SHAFT DIA (in.)	SHAFT LENGTH (in.)	LEAD CHARACTERISTICS STYLE	LEAD CHARACTERISTICS FINISH	LEAD CHARACTERISTICS SIZE (in.)	ELECTRICAL RATING	APPROX PRICE	REMARKS OR SPECIAL FEATURES
	PEPCO	[illegible]	[illegible]	10°	[illegible]		[illegible]	Dia.	[illegible]	[illegible]	[illegible]	None					
		[illegible]	[illegible]	45	2	[illegible]	3	Dia.	[illegible]	.250	[illegible]	None			10A @ 115 VAC		
		[illegible]	[illegible]	45°	[illegible]	[illegible]	[illegible]	Dia.	[illegible]	[illegible]	[illegible]	None			5A @ 115 VAC		
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			2A @ 125 VAC	[illegible]	Adjustable stops.
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			2A @ 125 VAC	[illegible]	Adjustable stops
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			2A @ 125 VAC	[illegible]	Adjustable stops
		[illegible]	[illegible]	36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	None			[illegible] VAC	[illegible]	Adjustable stops
		[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			[illegible] VAC	[illegible]	Adjustable stops every 30 [illegible]
Program Switch		[illegible]	[illegible]	[illegible]	N.A. Special	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None			20 Outputs [illegible]	[illegible]	[illegible]
Program Switch		[illegible]	[illegible]	[illegible]	N.A. Special		[illegible]	[illegible]	[illegible]		[illegible]	None			20 Outputs [illegible]	[illegible]	Separate in each position.
	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]			None			[illegible]		[illegible] Decks Avail.
	[illegible]	Type [illegible]	[illegible]		[illegible]		[illegible]	[illegible]				[illegible]	Nickel Plated	[illegible]	[illegible] VAC		Adjustable stops and spring return [illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	N.A. Special	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	None					[illegible]

ENCODERS

SHEET 1 OF 2

TRADE NAME	MFG CODE	MODEL NUMBER	TOTAL COUNT	ACCURACY	REV TOTAL COUNT	ROTATION FOR VALUE INCREASE	MOMENT OF INERTIA (gm - cm²)	BREAKAWAY TORQUE (oz - in)	OUTLINE DIMENSIONS (in.) LENGTH	WIDTH	DEPTH	SHAFT DIAMETER (in.)	SHAFT LENGTH (in.)	OUTPUT CODE	CURRENT	VOLTAGE	APPROX PRICE	REMARKS OR SPECIAL FEATURES
	AM [illegible]	ES [illegible]	Incremental	1:360	1	Either	30	0.05	2 1/4	Dia.	1 1/4	3/16	5/8	2 Phase Pulse		Up to 1.0 V		Magnetic readout
		544 A	256	1/256	1	CCW	30	[illegible]	2 1/4	Dia.	1 1/4	3/16	5/8	Gray		Up to 1.0 V		Magnetic read out
	Datex	[illegible]	128	1:128	1	Either	600	65	1.756	Dia.	1.5	.1871	54	Binary	2 ma	36V	$255 to $368	U scan
		[illegible]	128	[illegible]	1	Either	600	5	1.756	Dia.	1.5	.1871	54	Binary	2 ma	30 V	$ 296	V scan
		[illegible]	[illegible]	± 1 Part in [illegible]	1	Either	66	[illegible]	1.5	Dia.	1.0	.250	.75	Gray	20 ma	30 V	$ 395 to $ 495	Geared units available.
		[illegible]	[illegible]	± 1 Part in [illegible]	1	Either	22.6	1.5	5 1/2	Dia.	1.04	.500	.250	Gray	50 ma	30 V	$ 550	.375 in. Dia. through hole in shaft
	[illegible]	11-196	Incremental	1/600	1	Either	[illegible]	[illegible]	1.06	Dia.	1.30	.12	.444	2 Phase Sinusoidal		[illegible]		Optical
		11-506	Incremental	[illegible]	1	Either	[illegible]	[illegible]	1.06	Dia.	1.30	.12	.444	2 Phase Sinusoidal		[illegible]		Optical
	[illegible]	GRE 15-5	32	± 1/2 Digit	1	Optional	11	4	1.417	Dia.	1.25	.187	.69	Gray				
		2RE 15-9	512	± 1/2 Digit	1	Optional	81	4	1.417	Dia.	1.25	.187	.69	Gray				
		GRE 20-13	1024	± 1/2 Digit	1	Optional	11	5	2.000	Dia.	1.25	.249	.69	Gray				
		ADC 11-[illegible]	64	± 1/2 Digit	1	Either	6.2	4	1.062	Dia.	.75	.125	1.2	Binary	[illegible] ma	30 VDC		V scan with self selecting logic, multirevolution models avail.
		DADC [illegible]	128	1 Part in 128	1		NA							Binary				Detented, dual Optional
	[illegible]	787-8	128		1	CW	.0610	5	.75	Dia.	.60	.125	[illegible]	Binary	2 ma$_{max}$	120V$_{max}$	$ 420	V scan
		67-30	[illegible]		1	CW	00	4	1.75	Dia.	1.06	.187	.50	Binary	2ma$_{max}$	120V$_{max}$	$ 200	V scan
		718-62	1024		1	CW	1.5	75	4.19	Dia.	1.62	.25	.52	Binary	12ma	6V	$ 507	V scan
		713-10	8192		64	CW	94	4	1.75	Dia.	2.69	.187	.50	Binary	2ma$_{max}$	120V$_{max}$	$ 600	V scan
		722-31	100		1	CW	1.6	6	3.06	Dia.	1.06	.25	.56	BCD 8-4-2-1	2ma$_{max}$	120V$_{max}$	$ 340	Modified V scan
		723-31	2000		10	CW	1.4	8	3.06	Dia.	3.55	.25	.56	BCD 8-4-2-1	2ma$_{max}$	120V$_{max}$	$ 516	Modified V scan
		807-10	128		1	CW	.17	.50	1.75	Dia.	1.56	.187	.50	Binary			$ 690	U scan, magnetic
		778-11	256		1	CW	[illegible]	4	1.7	Dia.	.76	.187	.50	Gray	2ma$_{max}$	120V$_{max}$	$ 490	
		78-11	1024		1	CW	1.2	4	1.66	Dia.	1.64	.25	.56	Gray	2ma$_{max}$	120V$_{max}$	$ 501	
		757-24	128		1	CW	4	4.7	2.10	Dia.	2.07	.187	.50	Binary	2ma$_{max}$	120V$_{max}$	$2,90	Servo-resolver, modified V scan

ENCODERS

SHEET 2 OF 3

TRADE NAME	MFG CODE	MODEL NUMBER	TOTAL COUNT	ACCURACY	NO. TOTAL COUNTS	ROTATION FOR VALUE INCREASE	MOMENT OF INERTIA (GM - CM²)	BREAKAWAY TORQUE (OZ - IN)	OVERALL DIMENSIONS (IN.) LENGTH	WIDTH	DEPTH	SHAFT DIAMETER (IN.)	SHAFT LENGTH (IN.)	OUTPUT CODE	CURRENT	VOLTAGE	APPROX. PRICE	REMARKS OR SPECIAL FEATURES
	Litton	AD-11-08	256		1	CW	01	0.2	1.06	Dia.	1.30	.120	.72	Binary	6 ma	6 VDC	$ 600	V Scan
		AD-11-13	8192		32	CW	01	0.3	1.06	Dia.	1.05	.125	.72	Binary	6 ma	6 VDC		V Scan
	Norden	ADC-5T7-BNRY-5A	128	1 Part in 128	1		.07	0.6	1.63	Dia.	1 3/8	187	.56	Binary	1 ma	25 V		V Scan
		ADC-5T8-BNRY-2[illegible]	256		1				1.130	Dia.	2 3/4			Binary				
		ADC-5T7-BNRY-B	128	1 Part in 128	1		07	0.6	1.75	Dia.	1 9/16	187	50	Binary	4 ma	28 V		Self selecting V scan.
		ADC-5T8-BNRY	256		1				3.25	Dia.	1 29/64			Binary				Self selecting
		ADC-5T9-BNRY	512		1				3.25	Dia.	1 29/64			Binary				Self selecting
		ADC-5T10-BNRY	1024		1				6.22	Dia.	2 1/4			Binary				Self selecting
		ADC-5T8-GRAY	256	1 Part in 256	1		07	0.6	1.75	Dia.	1 1/8	.187	50	Gray	2 ma	25 V		With parity
		ADC-5T9-GRAY	512	1 Part in 512	1		17	0.5	4.25	Dia.	1 9/32	187	.50	Gray	2 ma	25 V		
		ADC-5T10-GRAY	1024		1				3.25	Dia.	1 29/64			Gray				
		ADC-5T3-36 BCD	360	1 Part in 360	1	Either	1.13	1.0	3.25	Dia.	1 31/64	.187	50	BCD 8-4-2-1	2.5 ma	28 V		Self selecting V scan degree counting.
		[illegible]/CPS BNRY	512 Plus Sign & Quad.		4				3.25	Dia.	5 3/8							Self selecting
		ADC-5T3 BCD	100	1 Part in 100	1		17	05	2.25	Dia.	2 1/64	187	50	BCD 8-4-2-1	3 ma	28 V		V scan
		ADC-3 BCD	1000	1 Part in 1000	10		17	05	2.25	Dia.	1 1/8	187	50	BCD 8-4-2-1	2 ma	28 V		V scan
		ADC-5T3 BCD(1000)	1000	1 Part in 1000	1		30	6.0	6.22	Sq.	2 3/8	.25	.75	BCD 8-4-2-1	2 ma	28 V		
		MADC 10/7/BY	128	± 1 count	1		13	05	1.75	Dia.	1.5	187	50	Binary	350 ma	3.5 VPTP		Magnetic output V scan
		MADC 10/3/BCD	1000	± 1 count	10		13	05	1.75	Dia.	1.8	187	50	BCD 8-4-2-1 or 8-2-4-1	350 ma	3.5V PTP		Magnetic V scan
		31-ADC-5T8 GRAY	256	1 Part in 256	1	CCW	0005	08	1.07	Dia.	1.41	187	41	Gray	2 ma	28 V		
	Theta	3B1A1	0-999.9	± 1 count	16	CCW	01	0.5	2.5	Dia.	3.6	187	.2	4 Digit Decimal	300 ma	24 V	$ 600	
		3B1A1	0-179.9	± 1 count	16	CCW	01	0.5	2.5	Dia.	3.6	187	.6	4 Digit Decimal	300 ma	24 V	$ 750	
		5B1A1	10,000	± 1 count	100	CCW	01	0.5	2.5	Dia.	3.6	187	6	4 Digit Decimal	100 ma	24 V	$ 500	One revolution units available.
	Wang	05A	1000		1			> 0.5	6.0	Dia.	3.9			BCD			$ 950	Optical
		03-1000	1000	± 1 count	1	NA		0.1				1/4	1 1/2	Incremental				Optical
		03-100	100	± 1 count	1	NA		0.1				1/4	1 1/2	Incremental				Optical

TWO-DIMENSIONAL CONTROLLERS: JOYSTICK

MANUFACTURER	MODEL NUMBER	TYPE	HANDLE STYLE	HANDLE SIZE	DISPLACEMENT	OPERATING FORCE	OVERALL SIZE (LESS HANDLE)	OUTPUT	APPROX PRICE	SPECIAL FEATURES
Bomar Inst. Corp.	X-1082	Positional Self Centering	Cylindrical	~ 1" Dia. by 4 1/2" long	± 30°		5 1/2" sq. x 3 1/4" Hi (incl. Pots)	X & Y Pots	$ 850	Thumb switch in handle dead zone switch.
Bomar Inst. Corp.	X-2438	Positional Self Centering	Cylindrical	.187" Dia. by 1 1/2" long	± 30°		1 1/4" sq. x 1 1/2" Hi (Less Pots)	X & Y Pots	$ 425	
Houston Fearless Corp.	NRI MARK II	Positional Self Centering	Tapered Cylinder					X & Y Pots	$577	Adjustable dead zone dead zone switch.
Measurement Systems Inc.	433	Pressure (Stiff Stick)	Small Knob On Round Shaft	4" long	0°	10 to 20 lbs for Max. Output	~4" Dia. by 3" Hi	X & Y Voltage ± 2VDC @10 to 25 lbs Linear with Pressure	$1500	
Pneumo Dynamics Corp.	460A	Positional Self Centering	1" Dia. Knob on 3/8" Shaft	2 1/8" long		14 oz or more for Max Deflection	~ 5" Dia. by 2 1/4" Hi (incl. Pots)	X & Y Pots or Synchros		Thumb switch in handle custom designs available.
Pneumo Dynamics Corp.	460B	Positional Self Centering or With Locking Brake	Tapered Cylinder	~ 1/2" Dia. by 2.6" long	± 30°	14 oz or more for Max Deflection	4.66" Dia. by 2 3/8" Hi (incl. Pots)	X & Y Pots	$200 to $600	Thumb switch handle avail.

APPENDIX II

BIBLIOGRAPHIC REFERENCES AND SUMMARIES

Bibliographic listings of reports pertaining to operator performance on conventional input devices considered during the effort are arranged herein in three categories; summarized references, rejected references, and references not reviewed. Within the first two categories references are further divided according to the type of device used in the reported research. Where more than one type of device was studied in a given report, the reference is repeated under each appropriate category.

Report summaries, which follow the bibliographic listings, are not intended to serve as annotated bibliographies. Rather, they represent extraction of those details judged to be of direct interest to this study.

APPENDIX II

References

Toggle Switch Performance Data

(Summarized References)

Bradley, J. V., Effect of Gloves on Control Operation Time. WADC TR 56-532, November 1956.

Bradley, J., and Wallis, R.A., Spacing of On-Off Controls II: Toggle Switches. WADC TR 58-475, March 1959.

Crumley, L. M. A Study of the Requirements for Letters, Numbers, and Markings to be used on Transilluminated Aircraft Control Panels: Part 7. An Evaluation of the Relative Manipulability of Simple Toggle Switches, Culter-Hammer Lock-Lever Toggle Switches, and Toggle Switch-Switch Guard Combinations. Naval Air Material Center Rpt. TED-NAM-EL-609, 16 Feb. 1953.

Henneman, R. H., and Outcalt, N. R., The Influence of Setting Cues on Manual Response Made to Following-Instructions Messages. WADC-TR-54-365, April 1955.

Siegel, A. I., Schultz, D. G., and Lanterman, R. S. Factors Affecting Control Activation Time. J. Human Factors Society, Vol. 5, No. 1, 71-80, February 1963.

Stump, N. E., Toggle Switches: Activation Time as a Function of Spring Tension. WADC-TN-52-39, August 1952 (a).

Stump, N. E., Toggle Switches-Activation Time as a Function of the Plane of Orientation and the Direction of Movement. WCRD-TN-52-51, Sept. 1952(b).

Lever Switch Performance Data

(Summarized References)

Bradley, J. V., Effect of Gloves on Control Operation Time. WADC TR-56-532, November 1956.

Minor, F. J., and Revesman, S. L., Evaluation of Input Devices for a Data Setting Task. J. Appl. Psychol., 46(5), 332-336. Oct. 1962.

Rocker Switch Performance Data

(Summarized Reference)

Page, D. E., and Goldberg, I. A., Human Factors Evaluation of a Keyset Entry Technique for Frequency and Channel Selection. International Telephone and Telegraph Laboratories, 1959. ASME Publication Paper No. 60-SA-38.

Thumbwheels Performance Data

(Summarized Reference)

Wade, Edward A., and Cohen, Edwin, Population Sterotypes in the Direction of Motion of Thumbwheel Switches, Human Factors, Vol. 4, No. 6, Dec. 1962, p. 397-399.

Pushbutton and Keyboard Performance Data

(Summarized References)

Adams, H. L., The Comparative Effectiveness of Electric and Manual Typewriters in the Acquisition of Typing Skill in a Navy Radioman School. J. Appl. Psychol., 41(4), 227-230, August 1957.

Alluisi, E. A., and Martin, H. B., An Information Analysis of Verbal and Motor Responses to Symbolic and Conventional Arabic Numerals. J. Appl. Psychol., 42(2), 79-84, April 1958. (also WADC-TR-57-196)

Alluisi, E. A., and Muller, P. F., Jr., Rate of Information Transfer with Seven Symbolic Visual Codes: Motor and Verbal Responses. WADC TR-56-226, May 1956.

Alluisi, E. A., Muller, Paul, F., Jr., and Fitts, P. M., An Information Analysis of Verbal and Motor Responses in a Forced-Placed Serial Task. J. Exp. Psychol., 53(3), 153-158, March 1957.

Anderson, N. H., Grand, D. A., and Nystrom, C. O., Performance on a Repetitive Key Pressing Task as a Function of the Spatial Positioning of the Stimulus and Response Components. WADC TR-54-76, March 1954 (See also J. Appl. Psychol, 40(3), 137-141, 1956).

Bradley, J. V., Effect of Gloves on Control Operation Time. WADC TR-56-532, November 1956.

Bradley, J. V., and Wallis, R. A. Spacing of On-Off Controls: I Pushbuttons. WADC TR-58-2, April 1958.

Braunstein, M., and Anderson, N. S., A Comparison of Reading Digits Aloud and Keypunching. IBM Research Center, Rep. RC 185, November 1959.

Conrad, R., Accuracy of Recall Using Keyset and Telephone Dial, and the Effect of a Prefix Digit. J. Appl. Psychol, 42(4), 285-288, 1958.

Diehl, M. Joan and Seibel, R., The Relative Importance of Visual and Auditory Feedback in Speed Typewriting. J. Appl. Psychol., 46(5), 365-369. October 1962 (See also IBM Rept. RC 278 July 1960).

Deininger, R. L., Human Factors Engineering Studies of the Design and Use of Pushbutton Telephone Sets. Bell Sys. Tech. J., XXXIX (4), 995-1012, July 1960.

Droege, Robert C., and Hill, Beatrice M., Comparison of Performance on Manual and Electric Typewriters. J. Appl. Psychol., 45(4), 268-270, August 1961.

Garvey, W. D., Operator Performance as a Function of Statistical Encoding of Stimuli. J. Exp. Psychol., 54(2), 109-114, August 1957.

Griffith, R. T., The Minimation Typewriter Keyboard, J. Franklin Institute, November 1949, 339-436.

Hillix, W. A., and Coburn, R., Human Factors in Keyset Design. USN Electron. Lab. Res. Rep., 1961, No. 1023.

Hopkins, H. F., Pushbutton "Dialing". Bell Laboratories Record, March 1960, 83-87.

Klemmer, E. T., Rate of Force Application in a Simple Reaction Time Test. J. Appl. Psychol., 41(5), 329-332, October 1957(a).

Klemmer, E. T., Rhythmic Disturbances in a Simple Visual-Motor Task. AFCRC TN-55-3. 1957(b).

Klemmer, E. T., A Ten-Key Typewriter. IBM Research Memorandum RC-65, 1958.

Elemmer, E. T., and Muller, P. F., Jr., The Rate of Handling Information: Key-Pressing Responses to Light Patterns, USAF Human Factors Operations Research Laboratories Memo Report No. 34, 1953.

Knowles, W. B., and Newlin, E. P., Reduction Coding in Responding to Signal Sequences. J. Appl. Psychol., 41(4), 257-262, August 1957.

Lockhead, G. R., and Klemmer, E. T., An Evaluation of an 8-Key Word-Writing Typewriter. IBM Research Report RC-180, 1959.

Lutz, Mary C., and Chapanis, Alphonse, Expected Locations of Digits and Letters on Ten-Button Keysets. J. Appl. Psychol., 39, 314-317, 1955.

Maxwell, W. C., The Rhythmic Keyboard, J. of Business Education, April 1952, 327-330.

Minor, Frank J., and Revesman, Stanley L., Evaluation of Input Devices for a Data Setting Task. J. Appl. Psychol., 45(5), 332-336, October 1962.

Muller, Paul F., Jr., Efficiency of Verbal Versus Motor Responses in Handling Information Uncoded by Means of Colors and Light Patterns. WADC TR-55-472, December 1955.

Newman, K. M., Coburn, R., and McMahan, R. C., Experimental Study of Binary Coded Keysets NEL Report 1137, 24 Sept. 1962. (also published in J. Eng. Psy., Jan. 1963, 32-43.)

Page, D. E., and Goldberg, I. A., Human Factors Evaluation of a Keyset Entry Technique for Frequency and Channel Selection. International Telephone and Telegraph Laboratories, 1959. ASME Paper 60-SA-38.

Ratz, H. C., and Ritchie, D. K., Operator Performance on a Chord Keyboard, J. Appl. Psychol., 45(5), 303-308, October 1961.

Scale, Edythe M., and Chapanis, A., The Effect on Performance of Tilting the Toll-Operator's Keyset. J. Appl. Psychol, 38(6), 452-456, Dec. 1954.

Seibel, R. Discrimination Reaction Time as a Function of 1) The Number of Stimulus-Response Pairs, and 2) The Self-Pacing Adjustment of the Subject. IBM Research Research Paper RC-562, November 13, 1961.

Seibel, R., Performance on a Five-Finger Chord Keyboard. J. of Appl. Psychol., Vol. 46, No. 3, 165-169, 1962(a).

Seibel, Robert, Discrimination Reaction Time for A1, 023 Alternative Task, IBM Research Report RC 789, Sept. 17, 1962(b).

Strong, E. P., A Comparative Experiment in Simplified Keyboard Retraining and Standard Keyboard Supplementary Training, General Services Admin., Washington, D. C., 1956.

Wassertheil, Sylvia M., Evaluation of Two Types of Manual Input Pushbuttons. AFCCDD TN 61-4, November 1960.

Webb, S., A Comparative Study of Six Keyset Entry Units. NEL Report 902, February 1959.

Webb, S., and Coburn, R., Development and Testing of a Hand-Configurated Keyset. NEL TM 357, September 1959.

Paige, Joeann C., and Hirsch, R. S., Human Factors in Keyset Design: An Annotated Bibliography, IBM Adv. Sys. Dev. Div. Lab., San Jose, Calif., Report No. 16,18,082,023 Feb. 15, 1961. (Tufts University Bibliography on Keyset Design.)

Rotary Control Performance Data

(Summarized References)

Bradley, J. V., Direction-of-Knob-Turn Stereotypes. J. Appl. Psychol., 43(1), 2-124. February 1959. (See also WADC TR-57-388, July 1957.)

Bradley, J. F., and Stump, N. E., Minimum Allowable Knob Crowding, WADC TR-55-455, December 1955(a).

Bradley, J. V., and Stump, N. E., Minimum Allowable Dimensions for Controls Mounted on Concentric Shafts. WADC TR-55-355. December 1955(b).

Bradley, J. F., and Arginteanu, J., Optimum Knob Diameter. WADC TR-56-96, November 1956.

Churchill, A. V., Manipulability of Braille Control Knobs. Canad. J. Psychol., 9(2), 117-120, 1955.

Davidson, A. L., Devoe, D. B., Spragg, S. D. S., and Green, R. F., Accuracy of Knob Settings as a Function of: 1) The Plane in Which the Knob Turns; and 2) The Diameter of the Knob. USN Special Devices Center Human Eng. Report SDC 241-6-8, January 1953.

Greek, D. C., and Small, A. M., Jr., Effect of Time Limitation on Marking Settings on a Linear Scale. J. Appl. Psychol., 42(4), 22-226, August 1958.

Chapanis, Alphonse, Studies of Manual Rotary Positioning Movements: I The Precision of Setting an Indicator Knob to Various Angular Positions, J. Psychol., 31, 51-64, 1951(a).

Churchill, A. V., Manipulability of Braille Control Knobs. Canad. J. Psychol., 9(2), 117-120, 1955.

Davidson, A. L., Devoe, D. B., Spragg, S. D. S., and Green, R. F., Accuracy of Knob Settings as a Function of: 1) The Plane in Which the Knob Turns; and 2), The Diameter of the Knob. SDC 241-6-8, January 1953.

Green, R. F., Accuracy of Setting Control Knobs as Functions of Directions of Final Movement and Number of Settings. ONR SDC TR-241-6-16, August 1955.

Jenkins, W. L., Mean Least Turn and Its Relation to Making Settings on a Linear Scale. WADC TR-57-210, May 1957.

Jenkins, W. L., and Connor, Minna B., Some Design Factors in Making Settings on a Linear Scale. J. Appl. Psychol., 33(4), 395-409, August 1949.

Jenkins, W. L., Maas, L. O., and Rigler, D., Influence of Friction in Making Settings On a Linear Scale. J. Appl. Psychol., 34, 434-439, 1950.

Minor, Frank J., and Reversman, Stanley L., Evaluation of Input Devices for a Data Setting Task. J. Appl. Psychol., 45(5), 332-336, October 1962.

Simon, J. R., and Simon, Betty P., Duration of Movements in a Dial Setting Task as a Function of the Precision of Manipulation. J. Appl. Psychol., 43(6), 389-394, December 1959.

Smith, S. L., Heading Estimation. MITRE Corp., TM-222, 10 July 1959.

Spragg, S. D. S., and Devoe, D. B., The Accuracy of Control Knob Settings as a Function of Size of Angle to be Bisected, and Type of End-Point Cue. Percept. Mot. Skills., 6, 25-28, 1956.

Stump, N. E., Manipulability of Rotary Controls as a Function of Knob Diameter and Control Orientation. WADC TN-53-12, February 1953.

Swartz, Paul, et al., The Effects of Friction on the Accuracy of Knob Settings. USN Special Devices Center SDC TR-241-6-14, August 1955.

Weiss, Bernard, and Green, R. F., The Effects of Inertia on the Accuracy of Knob Settings. USN Special Devices Center Human Engineering Report SDC TR-241-6-9, January 1953.

Weldon, R. J., and Peterson, G. M., Effect of Design on Accuracy and Speed of Operating Dials. J. Appl. Psychol., 41(3), 153-157, June 1957.

Worms, P. F., and Goldsmith, C. T., Investigation of the Maximum Allowable Torque for Rotary Selector Knobs. Dept. of the Army Ordnance Project TN 2-8106, Technical Report 2551, November 1958.

Two-Dimensional Controller Performance Data

(Summarized References)

Anon, The Bowling Ball Cursor Control -- Construction and Evaluation. Defense Electronics Division, Lt. Mil. Electronics Department, General Electric Co., Utica, N. Y., 1960.

Baker, C. H., et al. Studies with the Free-Moving Stylus. DRML 61-134-14.

Carel, W., and Minty, W., Target Capture with a Small Joystick. General Electric Adv. Elect. Center R59-ELC22, 28 June 1959.

Doughty, J. M., Speed and Accuracy of Pursuit-Tracking Using the Joy-sphere Control with Different Ratios of Control Movement to Tracking-Pip Movement, AFCRC TN 58-5, July 1958.

Gibbs, C. B., and Bilney, J. M., Control Disturbances in a Tracking Task Due to Operating Pushbuttons on the Control Lever. British RNPRC Applied Psychology Research Unit Eng. Rpt. 55-840, April 1955.

Hedlum, J. M., and Coburn, R. A., Study of PPI Pickoff Devices, USNEL R&D Rept. 601, 9 May 1955.

Jenkins, W. L., and Karr, A. C., The Use of a Joystick in Making Settings on a Simulated Scope Face. J. Appl. Psychol., 38, 457-461, 1954.

Reed, J. D., Speed and Accuracy of Target Designation with Small Joy-stick Controls. RADC Final Rept. AF30(602)-573. (no date given.)

Thorton, G. B., A Comparison of an Experimental Rolling Ball Control and a Conventional Joystick in Speed of Tracking on a Simulated Radar Display. Defense Res. Med. Lab., Rpt. 197-1, 1953.

Sulzer, R. L., and Cameron, D. B., Tracking Studies: Joystick and Blanking Cartrac Comparisons. AFCRC OAL-TM-59-2, February 1959.

Pushbutton and Keyboard Performance Data

(Rejected References)

Chase, R. A., Harvey, S., Standfast, Susan, Rapin, Isabelle, et al. A Comparison of the Effects of Delayed Auditory Feedback on Speech and Key Tapping. Communications Lab., Department of Biometrics Research, December 1958.

Doty, L. A., Asher, J. W., Hanley, T. D., and Steer, M. D., The Relationship Between Listener Accuracy and Concurrent Psychomotor Activity. USN Special Devices Center Tech. Rep. 104-2-43, October 1955.

Dvorak, A., A One-Hand Keyboard for One-Handers. Handicap, April 1950.

Erskine, D. G., and Philips, W. D., Integrated Airborne CNI Control and Display Equipment Program. WADC TR-59-271, 4 June 1959.

Gebbard, J. W., and Glockman, R. W., Some Perceptual Problems in the Design of Coded Switching Keyboards. USN Special Devices Center Technical Report SDC 166-I-126, 10 October 1951.

Klemmer, E. T., and Lockhead, G. R., An Analysis of Productivity and Errors on Keypunches and Bank Proof Machines. IBM Research Report RC-354, 1960. (Also published as Productivity and Errors in Two Keying Tasks: A Field Study, J. Appl. Psychol., 46(6), 401-408, December 1962.)

Klemmer, E. T., The Rate of Handling Information: The Effect of Forced Intermittancy in a Key Pressing Task, AFCRC TR-54-53, December 1954.

Lee, W. A., and Snodgrass, J. G., On the Relation Between Numbering Preferences and Performance on a Ten-Button Keyboard. American Psychol. 13, 1958.

Lundervold, A., Electromyographic Investigations During Typewriting. Ergonomics, 1(3), 226-233, May 1958.

Morin, R. E., and Grant, D. A., Learning and Performance on a Key-Pressing Task as Function of the Degree of Spatial Stimulus-Response Correspondence. J. Exp. Psychol., 49, 39-47, 1955. (See also WADC TR-53-292, October 1953.)

Nystrom, C. O., and Grant, D. A., Performance on a Key Pressing Task as a Function of the Angular Correspondence Between Stimulus and Response Elements. Percept. Mot. Skills, 5, 113-125, 1955. (See also WADC TR-54-71, January 1954.)

Rulon, P. J., Brooks, W. D., and Baldwin, W. W., A Comparison of Two Methods of Teaching Typewriting. Educational Research Corporation, ERC Proj. 497, Letter Order 7 July 1958.

Rulon, P. J., Sampson, P. B., and Schahan, B., The Effects of "G" Forces on the Performance of Teletype Operators. USAF Air Material Command Tech. Rep. 6568, October 1951.

Stockbridge, H. C. W., Micro-Shape Coded Knobs for Post Office Keys. Tech. Memo. 67, March 1957. Clothing and Stores Experimental Establishment, Ministry of Supply, London, England.

West, L. J., Recommendations for Typewriting Training, AFPTRC TN-57-68, June 1957.

Rotary Control Performance Data

(Rejected Reference)

Anderson, R. G., An Improved Series of Single-Turn Shaft Digitizers, (Technical Note No. Maths 66), August 1961. AD 268 546.

Austin, T. R., and Sleight, R. B., Factors Related to Speed and Accuracy of Tactual Discrimination. J. Exp. Psychol., 283-287, 1952.

Bahrick, H. P., Bennett, W. F., and Fitts, P. M., Accuracy of Positioning Reponses as a Function of Spring Loading in a Control. J. Exp. Psychol., 49, 437-444, June 1955.

Bradley, J. V., Control-Display Association Preferences for Gauged Control, WADC TR-54-379, August 1954.

Bradley, J. V., Control Knob Arrangement Can Save Aircraft Instrument Panel Space. J. Aviat. Med., 28(3), 322-327, June 1957.

Bradley, J. V., Effect of Knob Arrangement on Consumption of Panel Space. WADC TR-56-202, June 1956(b).

Bradley, J. V., Tactual Coding of Cylindrical Knobs. WADC TR-59-182, September 1959.

Chapanis, Alphonse, Studies of Manual Rotary Positioning Movement II. The Accuracy of Estimating the Position of an Indicator Knob., J. Psychol., 31, 65-71, 1951(b).

Craik, K. J. W., A Note on the Design and Manipulation of Instrument Knobs. Gt. Brit. Med. Res. Council, Appl. Psychol. Unit, 46/772, January, 1945.

Crumley, L. M., A Study of the Requirements for Letters, Numbers and Markings to be Used on Transilluminated Aircraft Control Panels. USN Aeronautical Medical Equip. Lab. Rept. TED NAM EL 609, XG T 192, December 1948.

Green, B. F., and Anderson, Lois K., The Tactual Identification of Shapes for Coding Switch Handles. J. Appl. Psychol., 39, 219-226, August 1955.

Green, R. F., Zimiles, H. L., and Spragg, S. D. S., The Effects of Varying Degrees of Knowledge of Results on Knob Setting Performance. USN SDC TR-241-6-20, August 1955.

Holding, D. H., Direction of Motion Relationships Between Controls and Displays Moving in Different Planes. J. Appl. Psychol., 41(2), 93-97, April 1957.

Hunt, D. P., The Coding of Aircraft Controls. WADC TR-53-221, August 1953.

Hunt, D. P., and Warrick, M. J., Accuracy of Blind Positioning of a Rotary Control. WCLD TN 52-106, March 1957.

Jenkins, W. L., Design Factors in Knobs and Levers for Making Setting on Scales and Scopes: A Summary Report WACD TR 53-2, February 1953.

Jankins, W. L., Maas, L. O., and Olson, N. W., The Influence of Inertia in Making Settings on a Linear Scale. J. Appl. Psychol., 35, 208-213, 1951.

Jenkins, W. L., The Superiority of Gloved Operation of Small Control Knobs. J. Appl. Psychol., 42(2), 97-98, April 1958.

Peters, G. A., When Choosing Selector-Switch Knobs. Prod. Engng., 29 (50) 103.

Raines, A., and Rosenbloom, J. H., Ideal Torques for Handwheels and Knobs. Machine Design, 18(8), 145-148, 1946.

Reed, J. D., Factors Influencing Rotary Performance. J. Psychol., 28, 65-92, 1949.

Spragg, S. D. S., Some Factors Affecting the Setting of Dial Knobs. Amer. Psychologist, 4, 304, 1949.

Twyford, Loran, C., Jr., Time-Ordered Effects in Long Series of Knob Control Adjustment. USN Special Devices Center SDC TR-241-6-19, 1 August 1955.

Warrick, M. J., Direction of Movement in the Use of Control Knobs to Position Visual Indicators, and Appendix I. Air Material Command TSEAA-694-4c, April 1947.

Weiss, B., Coleman, P. D., and Green, R. F., Time-Ordered Effects in Long Series of Knob Control Adjustments. USN Special Devices Center SDC TR-241-6-19, August 1955.

Weldon, R. J., Yafuso, R., and Peterson, G. M., Factors Influencing Dial Operation II, Special-Purpose Double-Number Dials. Sandia Corp. Eng. Res. Report SC 3839 (TR), April 1956.

Two-Dimensional Controller Performance Data

(Rejected References)

Andreas, B. G., Finck, A., Green, R. F., Smith, S., et al. Two Dimensional Compensatory Tracking Performance as a Function of Control-Display Movement Relationships, Positioning vs Velocity Relationship, and Miniature vs Large Stick Control. J. Psychol., 48, 237-246, October 1959.

Andreas, B. G., Murphy, D. P., and Spragg, S. D. S., Speed of Target Acquisition as Functions of Knob vs Stick Control, Positioning vs Velocity Relationship, and Scoring Tolerance. RADC SR3, July 1945.

Anon, Evaluation of Track Stick Versus Track Ball, US Army Air Defense Board, Rept. of Evaluation, Project No. TF-2460, 15 March 1961.

Anon, Active-Passive Air Surveillance System for Experimental SAGE Sector (Jam-Track). IBM CD 6-408-6744.

Bahrick, H. P., An Analysis of Stimulus Variables Influencing the Proprioceptive Control of Movements. Psychol. Rev., 64(5) 324-328, 1957.

Birmingham, H. P., Comparison of a Pressure and Moving Joystick. NRL IR S-3600-33A-50, September 1950.

Cahow, J. N., and Wolbers, Harry L., An Investigation of Radar Hand Control Shapes and Movements in the Aero X24A Lock-On Procedures. Report No. ES-17845, Conf. Rept., 28 January 1955. AD 136 295.

Duetsch, J. J., and Herbert, M. J., The Development of a Static Target Apparatus and Tasks for the Study of Control and Reticle Characteristics. AMRL Rept. 187, May 1955. Fort Knox, Ky.

Godwin, A. C., and Wallis, D., Some Human Factors in the Design of Controls: An Evaluation of the Literature. Admiralty, London, Eng., Rpt. 61, October 1954.

Fluhr, F. R., Digitalized Pickoff Display Converter. NRL Rep. 5281, March 1959.

Fluhr, F. R., and McLaughlin, D. J., The Naval Data Handling System Pickoff Display Converter. NRL Rept. 5248, 8 January 1959.

Gottsdanker, R. M., The Continuation of Tapping Sequences. J. Psychol., 37, 1954.

Hartman, B. O., The Effect of Joystick Length on Pursuit Tracking. USA Medical Research Lab. Rep. 279, November 1956. Fort Knox, Ky.

Hicks, S. A., Literature Review: Tracking Control Mechanisms and Displays (Light Anti-Aircraft System Oriented). USA Ordnance Human Eng. Lab. Tech. Memo. 9-57, December 1957.

Howland, D., and Noble, M. E., The Effect of Physical Constants of a Control on Tracking Performance. J. Exp. Psychol., 46, 353-360, 1953.

Jenkins, W. L., and Olson, M. W1, The Use of Levers in Making Settings on a Linear Scale. J. Appl. Psychol., 36, 269-271, 1952.

Karroll, J. E., and Parsons, H. M., Studies in Circular Tag Positioning I. Effects of Distance and Angle of Movement M-3/A-II. Department of Electrical Engineering, Columbia Univ. Eng. Center, July 1955.

Katchmar, L. T., Physical Force Problems: I. Hand Crank Performance for Various Crank Radii and Torque Load Combinations. Human Eng. Lab. Aberdeen Proving Ground TM 3-57, March 1957.

Morrill, C. S., and Sprague, Linda T., Operator Preferences for Movement Compatibility Between Radar Hand Control and Display Symbology. J. Appl. Psychol., 44(3), 137-140, June 1960.

Muckler, F. A., and Matheny, W. G., Transfer of Training in Tracking as a Function of Control Friction. J. Appl. Psychol., 38, 364-367, 1954.

Siekmeier, D., An Apparatus for the Real Time Transmission of Handwriting and Map Information to Remote Displays, Project Michigan Rept. 2900-300-R, January 1962. AD 269-991.

Swartz, Paul, Norris, Eugenia B., and Spragg, S. D. S., Performance on a Following Tracking Task (Modified Sam Two-Hand Coordination Test) as a Function of Radious of Control Cranks. J. Psychol., 37, 163-171, 1954.

Wardrip, S. C., The Naval Data Handling System Capabilities in Position and Rate - Aided Target Tracking. NRL 5672, 6 October 1961.

Weiss, B., The Role or Proprioceptive Feedback in Positioning Responses. J. Exp. Psychol., 47, 215-224, 1954.

Bibliographic References Not Reviewed

Anon, Optimum Physical Design of An Alphabetical Keyboard, Part I: Survey of the Literature. Post Office Eng. Dept. Great Britain, Research Rept. No. 20412, Pt. 1, 19 December 1961.

Anon, Study of Canadian Rolling Ball Pickoff Device. NEL N5-1, 3 Dec. 1954.

Ford, Adelbert, Rigler, David, and Dugan, Genevieve E., Pantograph Radar Tracking: Point Centering, Experiments. J. Appl. Psychol., 34, 429-433, 1950.

Garvey, W. D., and Knowles, W. B., Pointing Accuracy of a Joystick Without Visual Feedback. J. Appl. Psychol., 38, 1954.

Gibbs, C. B., The Advantages of a Pressure Operated Control Lever in a Velocity Control System. British RNPRC Applied Psychology Research Unit Report 161/51, January 1952.

Green, B. F., and Anderson, Lois K., The Tactual Identification of Shapes for Coding Switch Handles. J. Appl. Psychol., 39, 219-226, August 1955.

Korothink, A., and Cornog, D. Y., Display-Control Compatibility. Westinghouse Human Factors Data Bull., 50, May 1960.

Rake, H., Typewriting Research Index: 1900-1954. Carbondale, Ill.: 807 Twisdale Avenue, 1954.

Weitz, J., Effect of Shape of Handles and Position of Controls on Speed and Accuracy of Performance when Visual Cues are Restricted. AAF School of Aviation Medicine, Proj. 351, Rept 1, March 1945.

Weldon, R. J., and Peterson, G. M., Factors Influencing Dial Operation: Three-Digit Multiple-Turn Dials. Sandia Corp. Eng. Res. Rpt. SC-3659 A (TR), February 1955.

APPENDIX II

REPORT SUMMARIES

Item: Toggle 1

Task: Activate a momentary toggle for a minimum period of time.

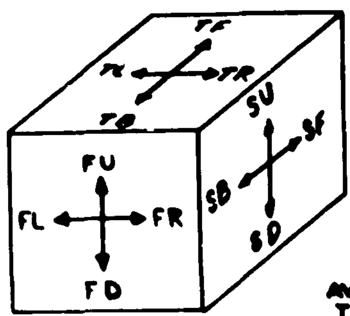
Stimulus: Verbal signal from E

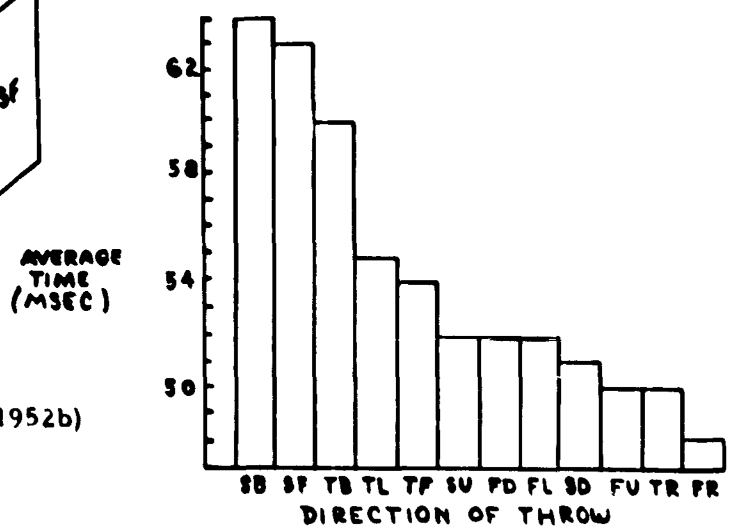
Subjects: 12 right-handed males

Response Mechanism: A single, 3-position (mom., maint., mom.) with operating force from center of 36 ounces. (Displacement est. 17°)

Conditions: Four directions of throw for each of 3 mutually perpendicular planes of activation. Six trials per S on each condition after 36 trial practice.

Results: See figure and legend below





Reference: After Stump (1952b)

Item: Toggle 2

Task: Reach and operate center of linear array of three toggle switches.

Stimulus: Single light

Subjects: 36 right-handed male college students

Response Mechanism: Three toggle switches in line on a vertical panel; type, spacing and row orientation controlled as experimental conditions.

Conditions: Three types of toggle switches used, not intermixed, one miniature and two standard differing in operating force, size and displacement. Experiment not designed to explore significance of these conditions individually. Three edge-to-edge spacings, 1/8" increments, studied for each switch type. Two orientation conditions, vertical in line and horizontal in line. Two throw direction conditions for each orientation. Total 36 conditions; each S had 10 trials per condition. S depressed telegraph key until stimulus appeared. Time to operate toggle measured from release of telegraph key to proper operation of center toggle.

S instructed to give equal weight to speed and accuracy.

Results: Mean reach and operation time (OT) across all conditions tested was 0.47 seconds (range 0.36 to 0.59 sec.) OT was consistently less for "down" direction of throw. OT was inversely related to spacing and, apparently, operating force, although

effects were small. OT for horizontial array was slightly faster than for vertical array. Mean operation errors 1.52% (range 0.00 to 9.72%). Operation errors consistently less for horizontal array. Operation errors inversely related to spacing and, apparently, operating force.

Operation errors less for down and right direction of throws.

Reference: After Bradley and Wallis (1959)

Item:	Toggle 3 (non-std. coding)
Task:	Locate and operate a sequential pattern of three momentary toggle switches in an 8 x 8 matrix.
Stimulus:	Projected letter-number combinations designating the column and row of each switch to be operated plus setting cues restricting the location and pattern of the next stimulus.
Subjects:	64 male college students
Response Mechanism:	64 two-position momentary action toggle switches arranged in an 8 x 8 matrix on a horizontal panel.
Conditions:	16 setting cue conditions, 4 area restrictions and 4 patterns restrictions. Setting projected for 5 seconds prior to stimulus presentation. 4 Ss per condition, 4 practice and 32 test trials per S. 3 feed back lights indicating correct operation of 1st, 2nd, and 3rd switch. All patterns used formed a right angle with adjacent switches. S held hand on starting block until stimulus onset. Stimulus remained on screen until 3rd switch operated. Operating time measured from stimulus onset to operation of 3rd switch.
Results:	Total operation time, for 3 switch sequence, varied as function of degree of setting from 9. 5 sec. for no area or pattern restructions (393 alternative) to 4. 0 sec. for maximum area and patterns restriction (3 alternatives).
Reference:	After Henneman and Outcalt (1955).

Item: Toggle 4

Task: Operate one of several controls of various types at onset of associated light stimulus.

Stimulus: One light above each on-off control, two lights with each adjustable control indicating direction of required movement.

Subjects: Thirty right-handed male college students.

Response Mechanism: A toggle switch, pushbutton switch, rotary control, horizontal lever control, and a vertical lever control each mounted on four identical vertical control panels arranged in a horizontal row in front of S.

Toggle switches were 3-position, momentary two sides, 20° displacement with bat handle 3/4" long by 1/4" dia. at end.

Conditions: Three "hand" conditions, bare hand, wool glove, and leather shell over wool glove.

Eleven "runs" per S per "hand" condition.

A "run" consisted of sequential operation of all controls on each panel.

Five different sequences used. All controls operated with the right hand. S kept hand on a timer key next to right armrest until stimulus onset. Time measured from release of key to operation of control.

S instructed to operate toggle to down position using thumb and forefinger.

Results: Average reach and operation times for toggles with bare hand (vs. location) ranged 0.451 to 0.596 seconds ($\overline{M}$ = 0.50 seconds). *

Reference: After Bradley 1956.

*See "Lever 1", "PB23", and "Rotary 13" for additional data from this study.

Item: Toggle 5

Task: Operate one of five toggle switches in response to light stimulus.

Stimulus: Five red lights, one above each switch.

Subjects: 12 right-handed adults. Only one had prior experience with toggles other than the common type.

Response Mechanism: Five different 2-position toggle switches mounted 1-1/4" inches apart in a horizontal row on a vertical panel in front of S.

Toggles were, from left to right, as follows:

a) A Cutler-Hammer "lock-lever" type toggle which locked in both up and down position. Toggle handle was the AMEL modification (1/2"x1/2" knurled cyliner). Toggle handle had to be pulled out before operating to overcome lock feature.

b) A standard two-position toggle with cover type switch guard (AN3028).

Guard pushed switch down when in the closed position.

c) A standard bat handle toggle

d) A "lock-lever" switch locked in the down position only and with the AMEL handle.

e) Same as (a) except with original C-H handle (smooth conical).

Conditions: Three lighting levels; 72.5 ft. candles of white light, 1 ft. candle of white light, and 0.05 candle of red light.

The positions of switches (a) and (e) were interchanged for

subjects 7 thru 12.

All subjects wore a metalic coated glove on their right hand.

Each S received 10 trials (5 for each movement direction) with each switch for each lighting condition. Switch order was random in a modified latin square design.

S required to sit upright with head on a headrest and right on knee until stimulus onset.

Operation time measured from time S's glove touched switch until switch was in its opposite position.

Results: Observations of the subjects made during the familiarization period indicated that subjects readily determined how to operate the "lock-lever" switches. However, most subjects pulled switch (d) before operating in either direction when it was necessary to pull only to push up. The switch-guard combination was more confusing to the subjects than the "lock-lever".

Operation times, exclusive of reach time, over all lighting conditions expressed in hundreds of seconds were as follows:

Switch	Direction of movement	Mean	Standard Deviation
A	down to up	42	21
B	down to up	50	28
C	down to up	25	17
D	down to up	42	21
E	down to up	50	20

Switch	Direction of movement	Mean	Standard Deviation
A	up to down	49	20
B	up to down	16	17
C	up to down	20	19
D	up to down	24	15
E	up to down	53	25

Means versus lighting condition increased from 0.30 seconds at 72.5 ft. candles to 0.48 seconds at 0.05 ft. candles

Reference: After Crumley (1953)

Item:	Toggle 6
Task:	Activate a momentary toggle for a minimum period of time.
Stimulus:	Unspecified but by association with other work probably a verbal command from E.
Subjects:	Ten
Response Mechanism:	Ten 3-position momentary action toggle switches with calibrated operating forces ranging from about 1/2 to 3 lbs. at the handle tip.
Conditions:	One switch at a time presented to S and mounted on a vertical panel with left-right direction of throw. S instructed to operate switch to the right and return to center as rapidly as possible while keeping hand on the switch. Time switch remained in right-hand position was measured. Operating forces presented in a random order with each S receiving 10 trials per switch with 4 replications.
Results:	Times ranged from about 80 to 89 milliseconds with analysis of variance showing no significant difference due to operating force.
Reference:	After Stump (1952a)

Item: Toggle 7

Task: Operate 3-position toggle switches in various arrays.

Stimulus: An illuminated card containing complete instructions for operation of the switch array.

Subjects: Paid university students and staff members, all right handed.

Response Mechanism: Various matrixes of 3-position toggle switches (AN3027-1 ST 50 P) mounted on a 24" sq. vertical panel located in front of seated S.

Number of switches, arrangement and spacing controlled as experimental variables. Switch operating forces from mid position 50 oz. to mid position 22 oz. each at end of 7/8" long handle.

Conditions: Groups of experiments were designed to determine the nature (rather than absolute magnitude) of control number, control density, activation sequence, control complexity, and link multiplicity (S-R compatability). Three subjects used for each of the five study areas.

Ss were practiced and received a "large number of trials."

Results: The control number and density studies showed linear and negatively accelerated increases respectively in total activation time over the parameter ranges of 2 to 30 switches and 1" to 8" spacing.

Average operation times ranged from about 0.29 to 0.51 sec

per switch.

The activation sequence and control complexity studies showed statistical but not practical differences for the examples tested. The link multiplicity studied showed a linear increase in total time for 5 switches as the number of links (decoding steps from stimulus to response) increased from 1 to 3 to 6 per switch. Task in all cases required operation of 5 switches in random sequence within a 10 x 10 matrix of switches. (Actual actuation time ranged from 1.8 to 6 seconds per switch.) Error rate was less than 2% throughout the studies.

Reference: After Siegel et al (1963)

Item:	Lever 1
Task:	Operate one of several controls of various types at onset of associated light stimulus.
Stimulus:	One light above each on-off control, two lights with each adjustable control indicating direction of required movement.
Subjects:	Thirty right-handed male college students
Response Mechanism:	A toggle switch, pushbutton switch, rotary control, horizontal lever control, and vertical lever control each mounted on four identical vertical control panels arranged in a horizontal row in front of S. Levers consisted of 1" dia. spheres on the end of a lever protruding 2-1/8" from the panel. Center of rotation 1-1/2" behind panel. Levers were continuously adjustable and required 30° displacement (centered on perpendicular) into 2° zone to extinguish stimulus light. An overshoot would turn on the opposite stimulus light.
Conditions:	Three "hand" conditions, bare hand, wool glove, and leather shell over wool glove. Eleven "runs" per S per hand condition. A "run" consisted of sequential operation of all controls on each panel. Five different sequences used. All controls operated with the right hand. S kept hand on a timer key next to right armrest until stimulus onset. Time measured from release of key for duration control was out of adjustment zone.

Results: Average reach and adjustment time with bare hand (vs. location) as follows: *

Horizontal lever		Vertical lever	
Range (seconds)	$\bar{M}$ (seconds)	Range (seconds)	$\bar{M}$ (seconds)
1.02 to 1.28	1.15	1.08 to 1.39	1.22

Reference: After Bradley 1956

*See "Toggle 4", "PB23", and "Rotary 13" for additional data from this study.

Item: Lever 2 (See PB 24)

Item:	PB 1
Task:	Apply Additional force to pressure key at stimulus onset.
Stimulus:	Light onset.
Subjects:	Six, various degrees of experience
Response Mechanism:	Pressure Key
Conditions:	S maintained given force of 0, 2, 5, 10 or 20 ounces on pressure key prior to stimulus. Reaction times (measured to first ounce and to twenty ounces of response) were analyzed as a function of changes in force required of response.
Results:	Little difference in RT versus holding force. RT to first ounce 164 to 169 msec. RT to twenty ounces 200 to 209 msec.
Reference:	After Klemmer (1957 a)

Item: PB 2

Task: Reach and operate center button in a linear arrav of three.

Stimulus: Single light onset

Subjects: Thirty-six, right-handed male college students each performed 10 trials under each of 36 conditions.

Conditions: Button diameter, spacing, and array orientation varied as follows:

Diameters: 1/2, 3/4, and 1 inch;

Spacing (edge-to-edge): 1/8, 2/8, 3/8, 4/8, 5/8, and 6/8 inch;

Orientation: Vertical and horizontal arrays on a vertical panel in front of S.

S held actuating finger on telegraph key until stimulus appeared.

S instructed to give equal weight to speed and accuracy.

Center button operating force: 21.55 (σ = 0.65) ounces

Left/upper button operating force: 24.00 (σ = 1.14) ounces

Right/lower button operating force: 24.65 (σ = 1.42) ounces

Time measured from release of telegraph key to operation of center switch.

Results: Performance with horizontal array better than with vertical array.

Overall mean operating time: 0.29 sec.

Overall mean operation errors: 0.9%

Reference: After Bradley and Wallis (1958)

Item:	PB 3
Task:	Press 1 of 5 keys
Stimulus:	Onset of 1 of 5 lights
Subjects:	Five
Conditions:	Constant stimulus repetition rate of two per second. The position of the lighted lamp was changed both regularly and randomly.
Results:	(1) For random stimuli, responses maintained a consistent phase relation to stimulus with a lag of approximately 0. 3 to 0. 4 seconds. (2) Regular stimuli led either to an irregular distribution of responses over the entire inter-stimulus interval or to a piling up of responses close to the stimulus.
Reference:	After Klemmer (1957 b)

Item: PB 4

Task: Press a sequence of up to four buttons in a 5x5 matrix

Stimulus: Onset of sequential pattern of lights in matrix corresponding to response buttons.

Subjects: Five naval enlisted men

Response Mechanism: (No additional data available)

Condition: S always knew number of lights to expect in sequence.

S responded after last light in sequence.

Signals presented in groups of 2, 3, or 4 items. 12 trials (60 signals each) per day for 18 days, each S. Self paced control trial (1 signal at a time) given at beginning and end of each day.

Inter-stimulus intervals of .37, .52, .68 and 1.02 seconds were used, but only one interval value per sequence. Self pacing by sequences.

Ss requested to try and reproduce order of sequence but error measures made only on basis of wrong button pressed without regard to order. Duration of each stimulus light 0.1 sec.

Results: Results based on last three trials.

Signals per sequence	Avg. punch out time per sequence (sec)	% Error of total signals	average time per signal (sec)
1	0.8	1/2	0.8
2	1.1	3/4	0.6
3	1.7	2	0.6
4	2.6	6	0.6

Error data indicates inverse relation with inter-stimulus interval. The delay period before the emission of the first response to a group of signals and the intervals between responses increased as a function of the number of signals per sequence.

Reference: After Knowles and Newlin (1957)

Item:	PB 5 (non-std. coding)
Task:	Press a pattern of 3 from a group of 8 keys.
Stimulus:	Group of 8 lights, lighted 3 at a time.
Subjects:	18 right handed male university students experienced and proficient on the task. S could not see response keyboard
Conditions:	Apparently a two-handed multiple press response was required. Three spacial locations each provided for stimulus and response panels. Key operating force 1/2 to 1 ounce. Row of green response lights provided above row of red stimulus lights. Both automatic and self pacing tested. S required to "reach and operate" during automatic pacing trials starting with hands on knees.
Results:	Best performance achieved with both stimulus and response panels in front of S. For this condition RT-1.68 seconds for automatic pacing; RT=1.38 seconds for self pacing Errors = 12.7% of press patterns during automatic pacing Errors = 7.2% of press patterns during self pacing
Reference:	After Anderson, Grant, and Nystrom (1954)

Item: PB 6

Task: Press any combination of 5 telegraph keys, multiple press task.

Stimulus: A combination of 5 white lights in front of keys. Direct spatial correspondence between lights and keys.

Subjects: 3 or 4 depending on part of experiment. All Ss had at least 6 days of practice on the apparatus.

Response Mechanism: Five telegraph keys arranged in an arc under the fingers of Ss preferred hand.

Conditions: Six separate but comparable tests involving different light patterns and pacing conditions. First 5 tests used all possible combinations, including none, 1, 2, 3, 4 and 5 lights with forced pacing rates of 2, 3, 4, and 5 stimuli per second. The sixth test used 31 combinations of lights (all except "none") under self pacing with 0.02 sec. delay between response and next stimulus. Total number of stimuli per S per test was 10 times the number of possible light patterns.

Results: Reaction time was not a function of stimulus presentation rate but was a function of task complexity, number of alternatives, as follows:

Alternatives	Avg. RT (seconds)
2	0.26
4	0.38
8	0.39

16	0.41
32	0.41
31 (self paced)	0.38

Performance degraded for stimulus presentation rates above 2 per second for all but the 2 alternatives condition. For the 2 alternatives condition performance did not degrade until 5 stimuli per second. Results for the 32 alternative condition indicate that degradation was associated with incorrect responses rather than an inability of the subject to respond at all.

Reference: After Klemmer and Muller (1953)

Item:	PB 7
Task:	Enter any combination of $\leq$ 5 into a 5 key keyboard, simultaneous press required.
Stimulus:	Onset of 1 or more of set of 5 lights corresponding in arrangement to the keyboard.
Subjects:	Four hired college students inexperienced on the task
Response Mechanism:	A modified IBM cardpunch numberic keyboard using the thumb bar and four button type row keys. All other keys covered and inoperative.
Conditions:	S used right hand in ready position over keyboard. Discrimination reaction time (DRT) and errors were measured for various combinations of stimulus patterns. Automatic pacing was used with random order of four delay times between response and next stimulus except one set of trials in which delay was constant, no time uncertainty (NUT). A total of 21,780 responses per subject extending over four months.
Results:	Effects of practice were still present at end of experiment. Mean DRT for all patterns during last cycle of experiment (310 trials per S) was about 0.35 seconds (σ = 0.05 sec). Mean RT (in which S knew which pattern was coming) for all patterns during last cycle of experiment (155 trials per S) was about 0.21 seconds (σ + 0.03 sec). Mean DRT for all

patterns during last cycle of experiment with NTU (310 trials per S) was about 0.34 seconds (σ = 0.04 sec.). Error rate (percent of responses in error) increased from about 4% to about 8% with inclusion of monetary incentive based upon speed and accuracy.

Reference: After Seibel (1961)

Item:	PB 8
Task:	Transpose any combination $\leq$ 5 into a 5 key multiple press keyboard, 31 alternatives.
Stimulus:	Five lights arranged same as keyboard
Subjects:	Four paid college students experienced on the task and apparatus.
Response Mechanism:	Modified IBM cardpunch numeric keyboard so that only 4 keys and thumb bar operative, all others covered and blocked.
Conditions:	Keys were operated with the right (favored) hand. All keys in a pattern had to be operated for simultaneity criterion within 0.1 second. New stimulus presented 2 to 3 seconds after correct response with deliberately introduced variability. Discrimination reaction time (DRT) measured from onset of stimulus to completion of correct response. Error responses not included in analysis of DRT's. Stimulus lights went out to indicate correct response. Random presentation of stimulus patterns.
Results:	Mean DRT for last five sessions (2635 trials per <u>S</u>) 0.32 seconds with a range over all patterns of 0.28 to 0.35 seconds. Mean error rate for last five sessions 9.9% with a range, all patterns, of 1.8% to 25.9%.
Reference:	After R. Seibel (1962 a)

Item: PB 9

Task: Press single button in 10x10 matrix, 100 alternatives

Stimulus: Matrix of lights corresponding to pushbuttons

Subjects: 30 in 5 matched groups

Response Mechanism: Detail not available

Conditions: Probability of occurrence for each light in stimulus matrix controlled in five different codes (probability patterns). Ss given 29 trials of 760 stimuli.

Results: No difference in performance due to code after practice. Response time after practice about 0.82 second.

Reference: After Garvey (1957).

Item:	PB 10
Task:	Enter 2-digit, limited letter-number combinations into SAGE pushbutton matrix, 150 combinations available.
Stimulus:	Printed letter-number groups in 4x12 matrix on sheet in front of S.
Subjects:	16 Air Force SAGE operators plus 6 native civilians
Response Mechanism:	Two vertical columns of pushbuttons on left wing panel of SAGE console. Left hand column had 15 buttons (numerals 0-6 plus letters G, H, J, K, L. M, N, & P) and the right column 10 (numerals 0-9).
Conditions:	Two types of buttons tested; flat with no edge-to-edge spacing and concave with 1/4" edge-to-edge spacing. An "Activate" button had to be pressed after entering each stimulus pair. Self paced trials. Ss instructed to achieve perfect performance. 144 stimulus pairs per S after 24 practice pairs.
Results:	No significant difference due to types of buttons. Mean entry time 2.86 seconds per stimulus pair.
Reference:	After Wassertheil (1960).

Item:	PB 11
Task:	Enter ("dial") 7-digit numbers in pushbutton telephone
Stimulus:	Standard telephone numbers consisting of 2 letters and 5 digits. Method of presentation unknown for sure, printed cards with single telephone number implied.
Subjects:	45 Bell Tel employees, no experience on task.
Response Mechanism:	A pushbutton telephone set with a composite of preferred characteristics isolated by preceding studies. (This presumably infers an operating force of 3-1/2 to 7 oz., 1/8" displacement without snap action and 1/2" square buttons spaced 3/4" between centers in two horizontal rows.)
Conditions:	The preferred composite set was tested with two other different composite pushbutton sets. Experiment design consisted of 15, 3x3 latin squares. Keying time measured from time of 1st keypressing to time of 7th keypressing.
Results:	No significant difference in performance versus type of composite set. Average keying time per number, 5.8 seconds. Average error rate, 2.3% of numbers keyed incorrect.
Reference:	After Deininger (1960).

Item:	PB 12
Task:	Enter a 10 digit telephone number in a toll-operators keyset.
Stimulus:	A list of 50, 10 digit telephone numbers consisting of 3 numerals, 2 letters, and 5 numerals.
Subjects:	Sixteen, 8 male and 8 female, without previous experience on the keyset.
Response Mechanism:	A long-distance telephone operator's keyset containing 10 push-buttons arranged in two vertical columns.
Conditions:	Performance versus 8 angles of keyboard tilt, 0 through 40 degrees investigated. Each S keyed 150 numbers in a practice session and 200 numbers during a test session. Incorrect numbers had to be re-keyed.
Results:	Effects of practice still present at end of experiment. Large individual differences. No significant differences due to tilt. All subjects preferred some slope to a horizontal angle and about 1/2 preferred a slope of 15 to 25 degrees. Mean keying time per number during test sessions about 9.5 seconds ($\sigma \cong$ 1.5 seconds). Mean error rate about 3% ($\sigma \cong$ 2%) of numbers keyed incorrect.
Reference:	After Scale and Chapanis (1954).

Item:	PB 13
Task:	Punch random digits on IBM 526 summary punch
Stimulus:	Booklet of random digits arranged 14 per line in groups of 3 and 4. Lines double spaced.
Subjects:	Two male and 3 female college students all with practice on an adding machine and desk calculator. (See also "Results", below.)
Response Mechanism:	Modified IBM 526 summary punch keyboard so that all keys covered and inoperable except the 10 digit keys and the card release key.
Conditions:	Experiment compared rate of reading digits aloud versus keypunching. Cards changed automatically after every 14th digit. <u>S</u> required to mark an error on card with pencil and repunch entire card. 3 practice plus 16 experimental sessions of about 5 minutes each.
Results:	The relatively untrained subjects used could read digits at about twice the speed at which they could keypunch them but found reading more tiring than keypunching. Average keypunching rate during experimental sessions was 1.32 digits per second (0.76 seconds per digit.) Undetected error rate-0.6% Detected error rate-0.4% An additional <u>S</u>, experienced at keypunching, was used for

two trials.

Her average rate was 2.80 digits per seconds (.36 seconds per digit). No errors were made.

Reference: After Braunstein and Anderson (1959).

Item:	PB 14
Task:	Transpose any combination $\leq$ into a 10 key multiple press keyboard, 1023 alternatives.
Stimulus:	Ten lights arranged same as keyboard.
Subjects:	Three IBM research staff members experienced on a limited subset, 31 alternatives, of the task.
Response Mechanism:	Five keys for each hand arranged in an approximate semi-circle. Spacing between thumb and index finger key greater than between other keys.
Conditions:	All keys in a pattern had to be operated within 0.1 second to meet multiple press criterion. New stimulus presented 2 to 3 seconds after correct response with deliberately introduced variability. Discrimination reaction time (DRT) measured from onset of stimulus to completion of correct response. Incorrect responses not included in analysis of DRT's. Stimulus lights went out to indicate correct response. Random presentation of stimulus patterns. Ss attempted to maintain a 10% error rate. Over 75,000 trials per S.
Results:	Asymptotic performance apparently reached after about 75 cycles (about 40,000 trials). Mean DRT about 0.41 seconds. Error rate about 12%.
Reference:	Seibel (1962 b)

Item:	PB 15 (non-std. coding)
Task:	Type text using a 10-key typewriter
Stimulus:	Random list of 1000 most frequent words in English. Words arranged in single vertical columns in groups of 60.
Subjects:	Two paid college students, one skilled in touch typing on a conventional keyboard.
Response Mechanism:	A 10-key keyboard with 5 keys for each hand arranged in a semicircle. Thumb keys used only for space and carriage return. Capital letters only could be typed. Each letter assigned a unique 1 or 2 key pattern from the 8 finger keys. Total travel of keys, 1/8", operating force 3.2 to 3.9 ounces. (Similar to IBM electric typewriter.)
Conditions:	Both keys of a pattern had to be pressed within 0.03 sec.
Results:	After practice and typing 12 and 19 groups of 1020 random words, _S_s, performance on 4 groups of 945 words of text were 29 and 47 "words" per minute, with error rates (wrong strokes) of 0.7 and 0.3% respectively.
Reference:	After Klemmer (1958).

Item: PB 16 (no-std. coding)

Task: Type whole words on an 8-key multiple press word-writing typewriter.

Stimulus: A selected list of 100 common English words. Also, text using these words.

Subjects: Four paid college students, 3 male and 1 female, all familiar with the standard 44 key typewriter. Ss not experienced on the multiple press task.

Response Mechanism: An 8-key keyboard with 4 keys for each hand arranged in an arc. Thumb keys present but inoperative. Key feel similar to that of IBM electric typewriter. Each word in the vocabulary had a unique press pattern using 3 to 7 of the 8 keys. (letters and numerals used 1 and 2 key patterns.)

Conditions: All keys of a pattern had to be pressed within 0.06 sec. Experiment consisted of the following sequence of different tasks:

(1) learning the 100 words

(2) speed trial with the 100 word vocabulary

(3) speed trial with a reduced (4 word) vocabulary

(4) learning letter and number code.

(5) re-learning the 100 words

(6) typing text

Subjects did not have an equal number of trials on the different tasks.

Results: Initial learning time, based on typing entire list correctly once, was 20 hours of practice.

On 100 word vocabulary speed trial, best performance on a 1000 word group was 72 wpm with a 5% error rate. On 4 word vocabulary speed total, performance ranged (versus subject) from 59 to 118 wpm for the last 1008 words after 2016 to 3024 words practice. Average error rate on this procedure was 8%.

When typing restricted text (composed of word patterns only) Ss operated at 36, 34, and 55 wpm for 15,500 total responses. Error rates not available.

Reference: After Lockhead and Klemmer (1959)

Item: PB-17

Task: Indicate expected locations of letters and numerals on 10 button keyboards of given configurations.

Stimulus: Booklets containing sets of given configuration and letters or numerals in random order.

Subjects: 300 adults equally divided between men and women and between naive and experienced on keyboard devices.

Conditions: Experiment divided into 3 parts with 100 Ss each.

Part I-S indicated expected locations of numerals in given unlabeled configurations.

Part II-S indicated expected locations of letters in given unlabeled configurations.

Part III-S indicated expected locations of letters in configurations with numerals already shown.

Six configurations tested, all based on 5x2 or 3x3/1 matrices.

Results: The numeral 0 always followed 9 and never proceeded 1. People expect to find numbers on keysets arranged in left-to-right order in horizontal rows starting with the top row. People expect to find letters on the keyset arranged in left-to-right order, with two or three letters in order on each key, in horizontal rows, starting with the top row.

Reference: After Lutz and Chapanis (1955)

Item: PB-18

Task: Press single key on 10-finger keyboard.

Stimulus: One of 10 symbols from 1 to 7 symbolic alphabets (codes) projected on viewing screen.

Subjects: 10 paid male students.

Response Mechanism: 10 pushbuttons in two groups of 5 on a horizontal surface. Each group arranged in an approximate semicircle corresponding to "natural" finger locations.

Conditions: 16 experimental sessions of 7 trials each per S. Each trial contained 100 random stimuli presentations from a given code set. First 6 and last 5 sessions were self paced. Center 5 sessions were forced paced. Second experiment was similar, but used verbal responses.

Results: Average performance on last 5 sessions, self paced, as follows:

Code	Percent Accuracy	Response Time (sec)
Arabic Numerals (2 types tested)	93.5	0.73
Line inclinations (3 types tested)	92.4	0.91
Ellipse-Axis Ratio and Color	88.9	1.00

Verbal performance superior on accuracy but inferior on speed.

Forced pacing inferior to self pacing.

Reference: Alluisi and Muller (1956).

Item: PB-19

Task: Press single key on 10 finger keyboard.

Stimulus: One of 10 lights corresponding in arrangement to the keyboard or one of 10 colors projected in center of a viewing screen.

Subjects: 96 female college students

Response Mechanism: 10 pushbuttons in two groups of 5 on a horizontal surface. Each group arranged in an approximate semi-circle corresponding to "natural" finger locations.

Conditions: A transfer of training design with both verbal response and motor response, both verbal and motor transfer tasks, and two types of stimuli, total of 6 conditions. Subjects divided into 8 groups. Five practice trials and five transfer trials per S of 100 stimuli each. All groups had same stimulus during transfer trials as they had during practice trials.

Results: Practice effects on color stimulus more pronounced than for spatial stimulus. Motor performance during transfer trials superior to verbal performance. Performance of transfer groups was inferior to that of control groups after transfer. Average reaction time to spatial stimulus with motor response during last trial was 0.5 seconds; with color stimulus and motor response RT was 1.0 seconds.

Reference: After Muller (1955)

Item: PB-20

Task: Selection of one of 64 alternatives with various keyset entry devices.

Stimulus: 1 of 64 typed word combinations presented in a window above keyset. For all but 1 keyset, S determined response associated with each word from a legend. The remaining keyset had a separate button for each word with an abbreviation of the word on the button.

Subjects: 8 Navy recruits.

Response Mechanism: One of four keysets containing 6, 7, 11, or 64 keys mounted on a panel 60^{o} from horizontal. The 11-key keyset consisted of 11 square buttons closely spaced in a horizontal row. The 6- and 7-key keysets used a portion of the 11-key row. The 64-key keyset consisted of square pushbuttons in a 10 column by 7 row matrix with only 4 buttons in the bottom row.

Conditions: Two instruction conditions, emphasize speed and emphasize accuracy. These two conditions were not intermixed. Four keyset conditions, 63 test items (entries) per trail; 8 trials per S inferred. S required to press an "Enter" bar after each entry.

Results: For both instruction conditions the 6-key unit yielded the fastest as well as the most accurate performance. Differences between keysets were small, however. Speed was greater

with the speed emphasis instruction and accuracy better with the accuracy emphasis instruction. Entry rates were in the vicinity of 10 per minute for both instruction conditions. Mean Error rate was about 3% during accuracy emphasis and about 5% during speed emphasis.

Reference: After Webb (1959) (Experiment II).

Item:	PB-21
Task:	Unknown task involving use of 16-key keyset and track ball.
Stimulus:	Unknown
Subjects:	Six college students
Response Mechanism:	Two types of 16-key keysets were used. One was a 4x4 matrix elevated 18° from horizontal. The other was a "hand configured" unit mounted at a compound angle.
Conditions:	Keysets operated with left hand without visual reference. Number of trials unknown.
Results:	Speed and error scores show slight advantage for the "Hand configured" set. Absolute meanings of speed and error scores not available. Therefore numbers not included here.
Reference:	After Webb and Coburn (1959).

Item: PB 22 (Also Rocker 1)

Task: Select 1 of 10 "channels" and adjust 5 digit decimal number ("channel frequency").

Stimulus: Visual presentation of channel designation and frequency in a horizontal window located approx. between <u>S</u>s knees. A ready light was located above and to the right of the window. The window opened 4 sec. after onset of ready light. Channel designation code used common abbreviations for typical aircraft communication channels such as TAC for Tacan.

Subjects: Five adult males, 4 right handed and 1 ambidextrous, none skilled on the apparatus.

Response Mechanism: <u>S</u>s station was a mocked-up single place aircraft cockpit. Response mechanism located on left-hand side console and consisted of 10 channel select pushbuttons arranged in 2 horizontal rows of 5 each plus 5 three-position, momentary 2 sides, rocker switches in a horizontal row. Each rocker switch was used to change the value of a corresponding decimal digit in an in-line display in front of <u>S</u>.

Conditions: Five experimental conditions of digit change rate:

1. Discrete pulsing; digit increased (or decreased) one step each time rocker key was pressed.
2. Slew rate of 2.1 digits per. sec.
3. Slew rate of 3.4 digits per. sec.

4. Slew rate of 5.6 digits per. sec.

5. Slew rate of 12.8 digits per. sec.

All Ss responded with their left hand. S pressed "channel" button before setting number. S required to press clock STOP button after entering digits.

Experimental conditions presented in either increasing or decreasing order, alternating on different days. 100 trials (per condition) per S on each of 4 successive days. Within each subset of 20 trials (5 digit numbers), all magnitudes of digit change occurred with equal frequency. E announced digit change rate prior to each subset. Rest period provided at end of 60 trials

Results: Pushbutton performance:

Mean time for selection response on last day of trial: 1.53 (σ 0.16) seconds. Average error rate over all trials and Ss: 0.7%

Rocker Performance:

Condition	Time(sec)* $\overline{M}$	σ	Error Rate (%)**
Discrete	8.6	1.4	1.5
2.1 d/s	9.9	1.7	2.5
3.4 d/s	9.1	1.2	1.0
5.6 d/s	8.8	1.5	2.25
12.8 d/s	9.0	1.6	0.75
$\overline{M}$ all conditions	9.0		1.6

* Last day only ** all days

The effects of practice were evident on all time scores through the 4th day.

Reference: After Page and Goldberg

Item:	PB 23
Task:	Operate one of several controls of various types on onset of associated light stimulus.
Stimulus:	One light above each on-off control; two lights with each adjustable control indicating direction of required movement.
Subjects:	Thirty right-handed male college students.
Response Mechanism:	A toggle switch, pushbutton switch, rotary control, horizontal lever control, and a vertical lever control each mounted on four identical vertical control panels arranged in a horizontal row in front of S. Pushbutton switches were momentary, 1/2" dia. convex button with 3/16" displacement.
Conditions:	Three "hand" conditions; bare hand, wool glove, and leather shell over wool glove. Eleven "runs" per S per "hand" condition. A "run" consisted of sequential operation of all controls on each panel. Five different sequences used. All controls operated with the right hand. S kept hand on a timer key next to right armrest until stimulus onset. Time measured from release of key to operation of control. S instructed to operate pushbutton with thumb.
Results:	Average reach and operation times for pushbuttons with bare

hand (vs. location) ranged 0.515 to 0.632 seconds ($\overline{M}$ = 0.58 sec.).*

Reference: After Bradley 1956

*See "Toggle 4", "Lever 1" and "Rotary 13" for additional data from this study.

Item: PB 24 (Also lever 2 and rotary 23)

Task: Enter a 10 digit number

Stimulus: A 10 digit number written on a card by S. S determined number by subtraction process not scored in experiment.

Subjects: 24 male production employees inexperienced on the types of devices to be tested.

Response Mechanism: Four input devices: (1) a 10-key keyboard, (2) a matrix keyboard, (3) a lever device, and (4) a rotary knob device. The 10-key keyboard was similar in arrangement to an IBM card-punch numeric keyboard (a type of 3x3+1) and had a visual accumulator and "clear" key. The matrix keyboard had a 9x10 matrix similar to some desk calculators. The lever device has 2 groups of five 10-position levers arranged in a horizontal row and all operating in a vertical plane along a curved surface. The rotary knob device had ten 10-position knobs with exposed moving scales arranged in a horizontal row. Fixed pointers were in the 12 o'clock position. In addition each device had a "transmit: key, a green "ready" light, and a red "in process" light.

Conditions: Each S processed and entered 175 10-digit numbers on each of the four devices. Four sets of 175 numbers were used with each S receiving a different set on each device. Entry time measured from entering of first digit in a number to pressing

of "transmit" key. S pressed "transmit" key after checking accuracy of entry. Errors based on percent of incorrect numbers "transmitted" by S with number written on stimulus card by S, whether correct substraction or not, taken as the correct value.

Each device approximately 45" from floor. (S assumed standing.) S processed and entered numbers in groups of three. At end of experiment S ranked the four devices according to his preference.

Results: Effects of practice present throughout trials for all devices but more pronounced for the lever device. Average time per entry over last 50 trials and error rate over all trials as follows:

Device	Entry Time (sec. per number)	Error Rate (% incorrect entries)	Preference
10-key	11	0.6	1
Matrix	12	1.2	2
Lever	16-3/4	2.3	3
Rotary Knob	17-3/4	2.3	3

Reference: After Minor and Revesman (1962)

Item:	PB 25
Task:	Transcribe light patterns on a multiple press keyboard.
Stimulus:	Two groups of 5 lights in a horizontal line above the keyboard on a tilted surface roughly perpendicular to the line of sight.
Subjects:	Six
Response Mechanism:	Two groups of 5 keys mounted in a horizontal surface and arranged in arcs under S's fingers. Keys operated snap action switches and required 3/8" displacement and "low pressure".
Conditions:	Three of the Ss used both hands throughout experiment and the other three used only one hand (right, preferred). Self paced trials, new stimulus appeared after S released all keys. Various sets of light patterns used. Different sets contained different pattern combinations i.e., all 2 finger or all 5 finger combinations. Within a set patterns occurred with equal frequency and in random order. Total of 2,660 measured reaction times. Reaction time measured from appearance of stimulus to completion of correct response and includes 0.1 second delay in stimulus presentation.
Results:	Negligible erroneous responses Little improvement in performance after second day (total 20 minutes of practice) with 31 alternatives. Median reaction time

(for 31 alternatives with one hand) 1.16 seconds, range versus pattern 1.02 to 1.48 seconds. About 65% of reaction time observed to be latency. Results of experiments using only selected groups of patterns as follows:

Experiment	Stimulus Chords	Patterns H (bits/stimulus)
One Hand		
A	1-finger chords	2.32
B	1-, 2-finger chords	3.91
C	1. 2-, 3, -finger chords	4.64
D	All chords	4.94
Two Hands		
E	1 finger per hand	4.64
F	All chords	9.91

Experiment	Observed Response Time T seconds/ response	Observed Data Rate H/T (bits/sec.)
One Hand		
A	.94	2.4
B	1.07	3.7
C	1.15	4.1
D	1.20	4.1
Two Hands		
E	2.08	2.3
F	2.63	3.8

Reference: After Ratz and Ritchie (1961)

Item:	PB 26
Task:	Press one of 10 buttons (keys) in response to number stimulus.
Stimulus:	Numerals 1/4" high projected on a 10" dia. opal glass screen located 28" in front of S. Two types of numerals used; conventional (AND-10400) and symbolic (straight line figures formed from an eight-element matrix).
Subjects:	48 male students without prior experience on the apparatus or with the symbolic numerals.
Response Mechanism:	Two groups of 5 keys arranged horizontally in two semicircular under S's fingers.
Conditions:	Ss divided into two groups, one for each response condition, motor or verbal. Each S responded for one session of 5 trials on each of two successive days. In addition, 5 Ss from each group responded for 10 additional 5-trial sessions. Each trial consisted of 100 random stimuli from each of the two sets of numerals, total of 200 presentations. For motor response, S kept fingers over keys and pressed the one which corresponded to the stimulus. Trials apparently self paced. S instructed to respond as rapidly as possible but to make less than 5% errors.
Results:	Performance showed improvement throughout 12 sessions.

Performance for session 2 and sessions 7-12 as follows:

	Mean Response Time (sec)		Mean Error Rate %	
	Session 2	Sessions 7-12	Session 2	Sessions 7-12
Motor Responses				
Conventional Numerals	0.88	0.71	2.94	4.55
Symbolic Numerals	0.89	0.72	2.32	4.50
Verbal Responses				
Conventional Numerals	0.75	0.63	0.33	0.54
Symbolic Numerals	0.84	0.67	0.66	1.13

Reference: After Allussi and Martin (1958)

Item: PB 27

Task: Operate one of up to 8 keys in response to number stimulus.

Stimulus: Arabic numerals 0.25" high projected on a 10" dia. opal glass screen about 28" in front of S.

Subjects: 10 paid male students

Response Mechanism: 10 keys arranged horizontally in two semicircles under S's fingers.

Thumb keys were not used.

Conditions: Three stimuli/response alternative conditions; one of 2, 4, or 8.

Three stimulus presentation rates (1, 2, 3, per second); forced pace task.

Two response conditions; motor (key pressing) and verbal.

Ss pretrained on keypressing task for 16 days making 1400 responses per day. Pretraining used 7 different stimulus codes one of which was the Arabic numerals used in the experiment. Pretraining involved both self paced and forced paced tasks at rates varying between 0.6 and 1.8 stimuli per second.

Ss pertained additional 12 days with 700 responses per day for verbal responses.

During experiment each S made 100 responses to random stimuli on each of the nine experimental conditions for both types or responses.

Results: Speed and accuracy data not available. Results expressed in

information transmission rate (H_T) in bits per sec. H_T increased with bits/stimuli for both response modes and increased with presentation rate for verbal response but decreased with presentation rate for motor response.

Max. H_T for motor response (at 3 bits per stimulis and 1 stimulus per sec) was about 2.6 bits per sec. Max. H_T for verbal response (at 3 bits per stimuli and 3 stimuli per second) was about 7.8 bits per second.

Difference in performance versus response mode hypothesized by authors to be due to difference in S-R compatibility.

Reference: After Alluisi, Muller, and Fitts (1957)

Item: PB 28

Task: Transmit numerical data via various multiple press touch keyboards.

Stimulus: Typewritten lists of 64 or 80 numbers in binary, octal, decimal, or base 16 depending upon the keyboard being used.

Subjects: 7 Navy enlisted men in first experiment. A total of 20 adults in the second experiment including 6 from 1st group plus 5 female students and 9 male students.

Response Mechanism: Seven different keyboard arrangements each configured for 2 hand multiple-press touch operation. All configurations were set up by removing key buttons from a Monroe matrix keyboard adding machine. Only those buttons required for a given arrangement were left on.

Six of the keyboards used two semi-circular patterns with the available keys located approximately under the natural position of the fingers. The remaining keyboard used two three-by-three matrices. In all cases the numeral 0 required no keys to be pressed. Some of the keyboards required re-coding of the stimulus, from octal or decimal to coded binary.

Conditions: The first experiment was conducted to obtain a rough evaluation of the seven keyboards. Each of the seven subjects trained on from 1 to 3 different keyboards until their daily improvement in mean time was less than 4 seconds over 2 days. Ss

practiced for a total of 30 minutes each day with timed trials given during last half of this period. Ss used same stimulus set each day, until asymptotic performance was reached then they changed to a new set.

The second experiment studied more formally four of the seven keysets.

Five different subjects used each of the four keysets. Ss used a different stimulus set each day for a total of 14 days of practice and testing.

Ss were instructed to work as rapidly as possible without making too many errors and were told their speed and accuracy scores after each trial.

Results: All results expressed in information transmission rate (bits per second) based upon correct response rate and bits per response.

In the first experiment transmission rate on unfamiliar numbers varied from 3 to 5 bits per second versus keyboard type with six and 10 key binary (no re-coding required) the best. The eight key 16 alternative keyboard (re-coding from decimal with 2 state color required) was the poorest.

Performance at the end of the second experiment was about 5 bits per second with no statistically significant difference between keysets tested.

Reference: After Hillix and Coburn (1961)

NOTE: Reference contains extensive review of literature and discussion of factors relating to human performance on keysets.

Item: PB 29

Task: Enter a series of 29 bit messages each consisting of: 1 of 4 message types, 1 of 8 word types, and 6 decimal digits.

Stimulus: 15 different printed lists containing 32 messages each.

Subjects: Five college students

Response Mechanism: A total of five keyset configurations were tested including two basic configurations with variations in labeling and feedback displays. One basic configuration contained 8 keys consisting of 4 keys for inserting data in a BCD code by multiple press patterns, a ZERO Key, a STEP key, a CLEAR key, and a TRANSMIT key. The first seven of the keys were arranged in a "hand configured" arrangement for touch operation (BCD code). The other basic configuration used the same keys as the first keyset for numeric data entry but included 2 additional keys for entry of "message type" and 4 additional keys for entry of word type. These latter keys were used in a coded manner with multiple press operation required for some values. Feedback display for both basic configurations consisted of a 6x4 light matrix for numeric data and color coded and labeled light indicators for message and word type indication. These latter indicators were combined with the associated keys in the case of the second configuration. The feedback variation consisted

of covering the 6x4 binary matrix and adding 6 decimal indicators, the labeling variation was used with only the first keyset and consisted of removing the labeling on the word and message indicators and adding a binary code legend strip to the side of the keyboard.

All keyboards were 6" wide, inclined at an angle of 17^{o} to the horizontal, and arranged for right handed operations.

Conditions: Each S trained on each of the five configurations until time and error scores reached stable values, usually 4 or 5/45-minute sessions. Each S had 3 experimental trials, consisting of 32 message entries each, on each of the configurations.

Order of keyset presentation and stimulus list presentation counter-balanced within subjects.

Time was measured by an electric stop clock and recorded on film by a camera along with a picture of a remote keyset each time the TRANSMIT key was operated.

S's instructed to place equal emphasis on speed and accuracy but were to correct any detected errors by clearing and re-entrying.

Results: Time per trial ranged from 3.7 to 4.3 minutes with a large difference between the two basic keysets; 3.75 minutes for the first and 4.25 minutes for the second. Errors ranged for 1.35 to 2.1 (presumably number of incorrect messages per

trial) with an average of 1.75 for the 1st keyset and 1.4 for the second.

Reference: After Newman et al (1962)

Item:	PB 30
Task:	Enter telephone numbers via a dial or keyset
Stimulus:	Eight-digit decimal messages presented aurally from a type recorder via headsets. Digits within a message presented at a rate of 100/min.
Subjects:	24 female telephonists experienced in the use of both dial and keyset.
Response Mechanism:	A conventional dial telephone and a keyset consisting of two horizontal rows of circular keys numbered 1-5 and 6-0 from left to right located (one at a time) in front of seated S.
Conditions:	Experiment designed to test subjects accuracy of recall using the two devices and with and without the addition of a fixed prefix, the digit 0. Messages constructed so that each digit appeared an equal number of times in each digit position. A total of 80 messages arranged in 4 lists of 20. Each S tested under each condition with a different list. Experiment design used six 4x4 latin squares.
Results:	Mean number of correct messages (out of 20) per condition as follows:

Keyset	11.38
Dial	10.13
Keyset with prefix	9.04
Dial with prefix	6.96

Reference: After Conrad (1958)

Item: PB 31

Task: Enter seven digit numbers in pushbutton telephone sets.

Stimulus: Seven-digit telephone numbers.

Subjects: Twelve laboratory employees and about 170 telephone customers in each of two cities.

Response Mechanism: A pushbutton telephone with the pushbuttons arranged in a 3x3+1 matrix.

Conditions: One laboratory study and two field tests. Subjects in laboratory study entered 10 seven-digit numbers per day for 12 days. Field test customers operated the pushbutton set at their normal telephone using rates for several weeks.

Results: Pushbutton set performance after learning: about 5-1/2 sec to enter seven digits. Average rotary dial rate: about 9.4 sec for seven digits. After learning, pushbutton accuracy "approached" that with the dial. Customers reported increased speed and ease of use.

Reference: After Hopkins (1960)

Item: Keyboard 1

Task: Type 5-minute speed typing tests under different feedback conditions.

Stimulus: The 24 "Competent Typist Test" from 1956 and 1957 issues of "Today's Secretary". (Presumable text)

Subjects: 16 female IBM employees consisting of secretaries, stenographers, and typists with normal typing speeds of from 45 to 80 net words per minute.[1]

Response Mechanism: An IBM Executive, Model B electric typewriter.

Conditions: Four feedback conditions; normal, visual masking, auditory masking, and both visual and auditory masking.

Balanced order of presentation with each S receiving three 5-minute tests on each condition on each of 2 days. S given four 5-minute practice sessions under normal conditions prior to experiment and an additional practice session prior to conditions involving auditory masking under those conditions.

S instructed to type at a speed that would yield 5 errors per test. E instructed S after each test to aim for either speed or accuracy in the following test in order to meet the required error rate.

Maximum of 1 error per word but punctuation and formatting errors also counted.

Results: Average GWPM just over 70 with largest difference between

one condition and another 1.5 words per minute. Average NWPM* between 55 and 60 with largest difference between one condition and another just under 4 words per minute.

Reference: After Diehl and Seibel (1962)

*[1] Net words per minute (NWPM) equals gross words per minute (GWPM) minus 2 times errors per minute.

Item: Keyboard 2

Task: Type 10-minute typing tests

Stimulus: United States Employment Service Typing Test Forms Nos. 6 & 7

Subjects: 575 individuals with at least 6 months experience on the electric typewriter.

Response Mechanism: Electric and manual typewriters.

Conditions: Each S tested first on an electric typewriter using Test Form No. 6 then tested on a manual typewriter using Test Form No. 7

Results

	Electric	Manual
Words per minute		
Range	36-101	28-86
Mean	65.28	56.11
Standard Deviation	11.22	9.51
Errors		
Range	0-57	0-59
Mean	14.80	16.93
Standard Deviation	10.19	11.90

Reference: After Droege and Hill (1961)

Item: Keyboard 3

Task: Type 5-character mixed letter-number groups.

Stimulus: Fifty 5-character mixed groups of letters and digits. Total alphabet size of 36 characters.

Subjects: 40 students enrolled in a Naval Training Center Radioman School. Half of the students had prior typing experience.

Response Mechanism: Electric and manual typewriters.

Conditions: Ss divided into two groups each with 10 having prior typing experience. One group learned on manual typewriters while the other learned on electric then transferred to manual machines for the last week of a 4 week course.

Typing tests given each class day starting at end of 1st week.

Form of stimulus presentation unknow, may have been Morse code.

Performance score taken as number of 5-stroke (including space) "words" per minute minus number of errors per minute.

Results: Performance increased throughout training. Experiment indicated no advantage to initial training on electric typewriters if operators are eventually to operate manual typewriters.

Mean score for manual typewriter group at the end of the course 18.55 net words per minute.

Reference: After Adams (1957)

Item: Keyboard 4

Not an experiment report. The reference contains suggestions for revision of the typewriter keyboard to take better account of the relative strength of the individual fingers and to divide the work load between the two hands to provide more rhythmic operation.

Data establishing finger strength and a relative frequency of letters in the English alphabet are presented and a "rhythmic" keyboard design is presented.

Reference: After Maxwell (1952)

Item: Keyboard 5

Not an experiment report. The reference points out several inefficiencies of the standard typewriter keyboard and describes the design of a MINIMOTION keyboard claimed to overcome these defects in writing average English text. Appendices provide statistical data on the frequency of usage of letters, single and adjacent pairs, in average English, terminology for analyzing finger and hand motions in typewriter operation and comparative results of motion analyses on fourkeyboards; standard, MINIMOTION, Dvorak-Dealey, and a random design.

Reference: After Griffith (1949)

Item: Keyboard 6

Task: Type 1 minute and 5 minute tests on the Simplified (Dvorak-Dealey) Keyboard typewriter.

Stimulus: Typical Typewriting tests as used in formal teaching of typewriting (English text).

Subjects: 20 U. S. Government employees, female typists, tested by Civil Service Commission on typing ability, general intelligence, manual dexterity, et cetera and statistically selected and divided into two equal groups, experimental and control, by Bureau of Census.

Response Mechanism: Experimental group used typewriters equipped with the Simplified Keyboard, (by reference U. S. Patent No. 2,040,248). Control group used typewriters equipped with Standard keyboards. Arrangement of Simplified keyboard is based on frequency of use of letters and letter patterns in English language.

Conditions: Tests performed in context of a formal typewriting improvement course involving instruction, practice, and testing under direction of qualified instructor.

Experimental group first underwent retraining until their gross speed scores reached their previous Standard keyboard scores. Each group then received additional training to increase their performance.

Training sessions lasted 4 hours per day, 5 days a week.

Results: Control group required an average of 100 hrs. of training to regain original speed performance on the 1 min. test with a wide variation across subjects.

After completion of retraining, experimental group showed less speed improvement and lower accuracy than control group. Average absolute speed and accuracy scores at end of experiment were as follows:

	Speed (Gross words per minute)	Accuracy (Errors per test)
Experimental group		
1 minute test	95.5	6.9
5 minute test	66.2	13.4
Control Group		
1 minute test	113.0	4.2
5 minute test	81.7	8.8

Reference: After Strong (1956)

Item:	Rotary 1
Task:	Turn rotary knob to increase or decrease brightness of lamp.
Stimulus:	A single lamp mounted above the knob
Subjects:	150 male and 150 female college students
Response Mechanism:	Knob on vertical surface (presumable continuous control).
Conditions:	240 of the subjects were asked to increase or decrease the brightness of the lamp with 8 different instruction phases used. One trial per S. 60 of the subjects were merely asked to "turn the knob" with the light covered. One trial per S.
Results:	73% of the Ss turned the knob CW to increase or CCW to decrease the brightness of the lamp. This tendency was strongest when an increase was required, and when the instruction was phased in positive terms. 62.5% of all Ss turned the knob clockwise. This tendency is stronger for right-handed persons than for left-handed persons.
Reference:	After Bradley (1957, 1959)

Item:	Rotary 2
Task:	Adjust two rotary knobs in sequence to next index.
Stimulus:	Index markings on moving dials plus a light associated with each dial indicating when correct adjustment had been made.
Subjects:	24 right-handed Naval Enlisted Men.
Response Mechanism:	Two 1-1/2" dia. x 3/4" high knurled knobs mounted on a vertical panel one to right of S other to left of S. Knobs equipped with 4" moving dials. Knobs rotated freely but had friction to prevent rotation on release.
Conditions:	Four index markings per dial at unequal intervals, 70° min., 115° max. 2 types of dials used differing in width of index marks and thus precision required in setting (2° and 20° index marks) with 20 target marks. 4 experimental conditions consisting of 2 dial types and 2 locations. 4 sessions of 12 trials each, (3 on each of the 4 conditions). A trial consisted of 12 settings each on right and left dials. Manipulation and travel times measured. Perfect performance forced through light feedback indicating correct setting. S required to use right hand to manipulate both right and left knobs.
Results:	Based as last session: Left dial manipulation slightly faster than right for fine settings. Coarse setting (20°) about twice as fast as fine (2°) setting.

Average time coarse setting: 0.23 sec. Average time fine setting: 0.46 sec.

Average travel time between knobs: 0.13 sec.

Reference: After Simon and Simon (1959)

Item: Rotary 3

Task: Make blind adjustment of a knob to 1 of 20 orientations within 180° arc.

Stimulus: Presumably verbal instruction from E.

Subjects: 8 right-handed young adults.

Response Mechanism: Two bar knobs (1-1/2" x 1/2" x 3/16") mounted on a vertical panel, one to each side of S. Continuous adjustment.

Conditions: 400 settings per S, half with each hand without visual reference and 400 settings per S with a remote visual reference. Brief instruction period preceeding first set of trials. S required to leave his elbow in space and not touch panel. No time limit imposed on making adjustments.

Results: Settings to the horizontal (0°, 180°) and vertical (90°) made to greater precision than intermediate positions. Settings between 0° (left horizontal) and 90° show negative constant errors whereas those between 90° and 180° (right horizontal) show positive constant errors. The visual guide improved performance slightly in the vicinity of 45° and 135° settings.

Reference: After Chapanis (1951a)

Item:	Rotary 4
Task:	Make blind adjustment (angular bisecting) with rotary control knob.
Stimulus:	None
Subjects:	105 young men
Response Mechanism:	A 2.5" dia. knob mounted on a vertical surface in front of S. Angular limits indicated by neon lamps.
Conditions:	Seven values of control inertia from 0 to 11.2 lb ft.^{2} in 1.86 lb-ft^2 increments. Four values of angle to be bisected: 40°, 80°, 120°, and 160°. S sampled angle twice before bisecting. Each S made 5 settings at each angle but one inertia value per S. Setting recorded by E from calibrated disk.
Results:	Average error scores are positive indicating a tendency to overshoot the correct value. Inertia had no effect on accuracy. Absolute error tended to remain constant at about 2-1/2° across angle size thus percentage error decreased with increasing angle size.
Reference:	After Weiss and Green (1953)

Item:	Rotary 5
Task:	Adjust rotary control the least possible amount
Stimulus:	None. S apparently adjusted when ready.
Subjects:	80 to 20 depending on the part of the experiment
Response Mechanism:	A rotary control with characteristics controlled as experimental variables.
Conditions:	Knob shape, size, inertia loading, friction loading, location on panel, and axis orientation controlled in 9 separate parts of the study along with barehanded versus gloved and right versus left hand operation. Number of trials per S was 40 to 80 depending on the part of the study.
Results:	Mean least turn (MLT) is about 1^{o} for knobs of 1" dia. or more and increases to about 3^{o} for knobs of 1/8" dia. MLT is lower (about 20%) with knob position to the left of normal. (Normal defined as in front of right elbow when seated). MLT tends to be lower in the CCW direction for both right and left handed operation.
Reference:	After Jenkins (1957)

Item: Rotary 6

Task: Adjust a moving pointer on a linear scale.

Stimulus: A lighted insert on the linear scale plus a "Ready" warning signal.

Subjects: 8 to 20 paid students depending on the part of the study

Response Mechanism: A rotary control with characteristics controlled as experimental variables.

Conditions: Knob shape, size, location on panel, and axis orientation controlled in 9 separate parts of the study along with barehanded versus gloved and right versus left hand operation.

Four stimulus conditions, lighted insert 3/16" or 4" to right or left of pointer initial condition.

40 or 80 trials per S depending on part of experiment. Error tolerance on setting pointer on insert, 0.007". S started trial with hand on control.

Apparatus capable of variable C/D ratio but values used unspecified.

Results: Adjustment time (for knobs 1" dia. and over) about 1.5 sec. for 3/16" adjustment and about 2.3 sec. for 4" adjustment. Better performance with round knobs versus other shapes. Better performance with normal location (in front of right elbow) than at other locations tested.

Reference: After Jenkins (1957)

Item: Rotary 7

Task: Adjust a pointer on a linear scale

Stimulus: One of several lighted inserts along an 11-inch linear scale.

Subjects: 3 to 5 in various parts of study; 4 male including 2 Navy radar operators and 2 without experience, all right handed, plus 1 female, left handed and inexperienced on the task.

Response Mechanism: A rotary control knob mounted on a vertical panel at waist height in front of seated Ss right elbow. Knob diameter and D/C ratio (pointer movement in inches per rotation) controlled. Control resistance (friction) varied directly with the D/C ratio (100-300 grams at 2-3/4" diameter).

Pointer connected to knob through a pulley system.

Conditions: 20 lightedinserts .032" wide used, unequally spaced but symmetrical about the center of the scale.

All settings began with pointer, 0.025" wide, in center of scale. Scale at eye level.

20 settings, in scrambled order, per run. Knob diameter 2-3/4" except when a variable. Several independent but comparable experiments.

10 D/C ratios from 0.22 to 33.6 tested. 14 knob diameters from 1/2 to 4 inches tested. Utility of crank and effect of backlash, 0 to 20° in 1° increments tested.

Results: Best D/C ratio based on mea i total time and forearm action

potentials is in the region of 1 to 2.

This region appears to be uneffected by knob diameter or the presence of a crank or backlash. Mean total travel time for best D/C ratios were in vicinity of 2.0 to 2.5 seconds for 5/8" pointer travel and 3.0 to 3.5 sec for 2-5/8" pointer travel.

Wide variability across Ss and trials.

Error rates "very small".

Knob diameter found relatively unimportant as long as it can be grasped conveniently.

A crank does not help and may hinder performance.

Backlash has a relatively minor influence on performance.

References: After Jenkins and Connor (1949).

Item: Rotary 8

Task: Adjust a pointer on a linear scale

Stimulus: Lighted inserts at 5/8" and 25/8" (3-1/8") each side of center on a linear scale.

Subjects: Four male students

Response Mechanism: A rotary control knob 2-3/4" dia. mounted on a vertical panel at waist height in front of right elbow of seated S. Control resistance (friction) and D/C ratio (inches of pointer movement per rotation) controlled as experimental variables.

Conditions: 6 D/C ratios from 1.18 to 16.3

5 values of friction force from 100 to 1300 Gm. at edge of knob.

Lighted insert .032" wide, pointer .025" wide.

All settings began with pointer in center of scale (inferred from reference)

Results: With frictional force equalized at 300 gm. the best D/C ratio was 2.42, a slight increase over that for the unequalized friction case. With D/C constant at 1.18 the best frictional force was the lowest tested, 100 gm. Effect of friction small for the smaller adjustment but considerable for the larger adjustment value. Mean total times per S per adjustment at 100 gm. and 1.18 ratio was 1.7 to 4.0 sec (mean 2.6) for 5/8" travel and 2.2 to 5.0 (mean 3.4) sec for 25/8" travel. Error data not available.

Reference: After Jenkins, Maas, and Rigler (1950)

Item:	Rotary 9
Task:	Set a three-digit number on a rotary dial or check a previously set number and correct if necessary.
Stimulus:	One of a set of instruction cards.
Subjects:	124 male college students.
Response Mechanism:	3 types of multi-turn rotary dials; (1) a top-reading two-disk vernier type, (2) a left-side-reading three-disk vernier, and (3) a 3 digit counter type. All dials capable of reading from 000 to 999 and about 1-3/4" max. outside diameter. Knob diameter considerably less on first two types. 10 turn dials are implied.
Conditions:	One type of dial only per S.
	Results based on operation of dials under "normal" illumination. Ss went in booths to set or check dials. Exact method for scoring setting time unknown but it was related to time S stood in front of the panel of dials. Randomness of number to be set and mean setting internal unknown.
Results:	Setting Performance:

Dial	No. of Settings	Mean Setting Time (sec.)	% Error
1	2600	12.2	4.96
2	1300	12.3	2.31
3	2300	9.8	1.52

Checking Performance:

Dial	No. of Settings	Mean Setting Time (sec.)	% Error
1	2600	7.0	3.96
2	1300	6.2	1.31
3	2300	3.8	0.83

Reference: After Weldon and Peterson (1957)

Item: Rotary 10

Task: Select 1 of 10 positions on a 10-position rotary selector switch.

Stimulus: Random numbers, size of set and method of presentation unknown.

Subjects: 10 right-handed males considered representative of population on the basis of dynamometer hand-strength tests.

Response Mechanism: A 10-position ball-detent rotary selector switch mounted on a vertical surface in front of S. Knob size and torque controlled as experimental variables. Fixed scale provided with numbers between 6 and 12 o'clock positions. Method of torque control modified detent action.

Conditions: All selections made from zero position in a clockwise direction with S's right hand. 5 knob types, all bar pointers 1-1/8" to 2" long. 4 torque values per knob type; 60, 80, 100 and 120 in-oz. S made 5 settings at each knob-torque combination. S required to complete setting prior to auditory signal controlled by E, i.e., stress simulator. Response timer controlled manually by E with foot pedal.

Results: Results based on total of 1000 settings. Range of mean setting times 0.8 to 1.1 seconds, median 1.0 seconds.

Largest knob resulted in the shortest times at all torques. The 80 in-oz. torque resulted in the shortest times for 3 of the 5 knobs.

Error rate, 1.3% of settings incorrect. Inverse relation between knob size and torque in relation to errors, i.e., large knobs and small torque or small knobs and large torque cause greatest number of errors.

Reference: After Worms and Goldsmith (1958).

Item: Rotary 11

Task: Estimate and report heading of simulated radar trials (tracks).

Stimulus: Simulated radar trials presented as a sequence of black dots on white paper. Sixty different tracks presented, 4 per stimulus sheet. Track headings randomly distributed within 360°.

Subjects: Two groups; five airmen experienced in the use of a 16-position rotary selector switch for reporting heading estimates plus five civilians inexperienced on the task. All Ss were right handed.

Response Mechanism: A round black knob 2-1/4" dia. and 1" high mounted on a panel 30° from vertical and angled toward S about 25° with respect to the stimulus display panel. A white arrow was pointed across the diameter of the knob but no index markings were on panel. Knob located 8" above table height and 22-1/2" left or right of the stimulus display panel.

Conditions: Three lengths of simulated radar trials (5/16", 1", 1-1/2"). Four response conditions, two manual (knob with left and right hand) plus two verbal (with and without calibrated azimuth reference scale.)

Counterbalanced factorial design.

Setting values recorded by E to nearest degree. Time per display sheet (4 trials) recorded to nearest second.

(Insufficient details provided on time scoring procedure to make use of absolute time measurements.)

60 trials per response condition per S.

Ss were not told how well they were doing during experiment.

Results: Wide individual differences on speed and accuracy for individual conditions. No difference in accuracy due to length of trials. Airmen faster but less accurate than civilians. Verbal (numerical) response slightly faster but less accurate than manual knob adjustment. Eight of the ten Ss indicated knob adjustment easier than numerical estimation.

Ss tended to round off numerical estimations to nearest 5 degrees.

Overall average error: for knob adjustment 5.9°, for numerical estimates 8.3°.

A tendency for right-handed adjustment to produce CCW errors and for left-handed adjustment to produce CW errors.

Reference: After Smith (1959).

Items: Rotary 12

Task: Set a moving pointer on a fixed scale

Stimulus: An oral command to set the pointer at a particular value. Dial was 3" dia. with 300° scale numbered clockwise every 10° with one degree scale marks.

Subjects: 72 flight cadets

Response Mechanism: One of eight differently shaped control knobs mounted on a vertical panel out of sight of S. Greatest dimension of each knob was 1-1/4". C/D ratio approximately 4:1. Pointer rotated in same direction as knob. Mounting permitted finger tip operation only. (Operating force not given.)

Conditions: Each S made 8 settings with each of the 8 different knobs. Settings for each knob involved pointer movements of 115°, 140°, 165°, and 230° both to CW and CCW, settings randomized for each S.

Errors recorded by E from 10" dial.

S instructed to avoid crossing 30° break in scale while making settings as quickly and accurately as possible. S kept hand on platform operating timer switch between trials. Platform in front and below control knob. (Hand used in setting not given.)

Results: Mean errors (vs. knobs) ranged 0.24° to 0.27° (about equal to pointer width). Mean setting time (vs. knobs) ranged 3.98 to 4.61 seconds. Best knob was a sphere; worst was a truncated six sided pyramid.

Reference: After Churchill (1955)

Item: Rotary 13

Task: Operate one of several controls of various types at onset of associated light stimulus.

Stimulus: One light above each on-off control; two lights with each adjustable control indicating direction of required movement.

Subjects: Thirty right-handed male college students.

Response Mechanism: A toggle switch, pushbutton switch, rotary control, horizontal lever control, and a vertical lever control each mounted on four identical vertical control panels arranged in a horizontal row in front of S. Rotary controls were continuously adjustable and required 40° displacement into 2° zone to extinguish stimulus light. An overshoot would turn on the opposite stimulus light. Control knobs were fluted, 1-1/2" dia. by 1/2" thick with 1" between back of knob and panel.

Conditions: Three "hand" conditions; bare hand, wool glove, and leather shell over wool glove.

Eleven "runs" per S per hand condition.

A "run" consisted of sequential operation of all controls on each panel.

Five different sequences used.

All controls operated with the right hand. S kept hand on a timer key next to right armrest until stimulus onset.

Time measured from release of key for duration control was

out of adjustment zone.

Results: Average reach and adjustment time for rotary controls with bare hands (vs. location) ranged 1.11 to 1.45 seconds ($\overline{M}$ = 1.24 sec.). *

Reference: After Bradley (1956a)

*See "Toggle 4", "Lever 1" and "PB23" for additional data from this study

Item: Rotary 14

Task: Adjust a control knob to extinguish a light stimulus.

Stimulus: A single amber light located above control knobs.

Subjects: Two groups each containing 24 right-handed male college students.

Response Mechanism: Round knobs arranged in one of four spatial configuration (crowding conditions) on a vertical panel in front of S. Knob diameter and edge-to-edge spacing controlled as experimental variables. Black index line on knob aided adjustment requiring approx. 120° displacement to 2° vertical zone to extinguish light.

Conditions: Spatial configurations: 5 knobs arranged in a cross (0 / 000 / 0)

3 knobs in a vertical array

3 knobs in a horizontal array

2 knobs in a horizontal array

Center knob only operated in first three configurations, left knob only operated in 2 knob configuration. Knob diameters of 1/2, 1, 1-1/2, and 1-3/4 inches used. Diameter and spacings not mixed within a configuration. S kept operating hand (right hand) on telegraph key until stimulus onset. Reach time measured from release of key to touch of knob.

Turning time measured from touch of knob to completion of adjustment (light extinguished).

Touching of adjacent knobs counted as an error with a maximum of one error count per trial.

Twelve trials per S per condition run as two experiments with not all possible conditions tested. Trials alternated CW and CCW adjustment. S instructed to avoid adjacent knobs while operating as fast as possible.

Results: Reach and turning times greater (roughly 20%) for 1/2" dia. knobs than for other sizes and decrease slightly for all diameters with increasing edge spacing. Slight increase in reach and turning times with an increase in the number of adjacent knobs, especially at closer spacings. Average reach time over all Ss and conditions: 0.60 sec. Average turning time over all Ss and conditions: 1.15 sec.

Touching errors occur more frequently on knobs to the right and below the operated knob. This trend was independent of the configuration tested.

Error rates decrease with increasing diameter and edge spacing; range (all conditions and Ss) 27.4 to 0%, average (all conditions and Ss) 5.5%

Reference: After Bradley and Stump 1955(a) (Experiments I and II).

Item:	Rotary 15
Task:	Select and adjust the proper control knob to extinguish a light stimulus.
Stimulus:	Nine lights arranged in an arc with random, but constant, association with control knobs. One light at a time turned on by E.
Subjects:	144
Response Mechanism:	Nine 1/2" diameter knobs (controlling potentiometers) arranged in a "closely spaced" square matrix. Spacing within matrix and position of matrix with respect to S controlled as experimental variables. Clockwise displacement of 130° required to extinguish associated light.
Conditions:	Six spacings of knobs within matrix (values not avail.). Eight locations of response panel in a 270° arc at shoulder level. Each S performed under only one combination of conditions and made 12 settings with each of the 9 knobs in a random sequence on each of 6 days. Ss wore gloves on 5th and 6th days and were required to fixate on a point below the stimulus on the 6th day. Reach time includes 20° to 25° of movement with the correct knob.
Results:	Averages for fourthday over all conditions and Ss (learning apparently complete):
	Reach time: 1.2 sec.
	Turning time: 0.7 sec.
Reference:	Bradley and Stump 1955 (a) (Experiment III).

Item: Rotary 16

Task: Reach and adjust a rotary knob to extinguish the stimulus light.

Stimulus: A single amber light located above the control and controlled by E.

Subjects: 48 right-handed male college students.

Response Mechanism: A single control knob mounted on a vertical surface in front of S. Knob diameter and torque controlled as experimental variables. Adjustment required CW or CCW displacement of about 125° into a 2° zone. A black index line on the knob aided adjustment; the line pointed up for proper adjustment. Inertia varied with knob diameter from nearly 0 at 1/2" diameter up to about 250 gm-in^2 at 3-1/2" diameter.

Conditions: 12 diameters ranging from 1/2" to 3-1/4" in 1/4" increments. Two shaft frictions: moderate -81 in-gm. avg.
heavy -176 in-gm. avg.

Each S made 6 CW and 6 CCW adjustments with each knob diameter but only one shaft friction. S kept operating (right) hand on telegraph key until stimulus onset.

Reach time measured from release of key to start of knob turning. Turning time measured from end of each time to completion of adjustment.

Results: Reach time was nearly constant at about 0.38 sec. from 3-1/4" dia. down to 1-1/2" dia. then increased to about

0.48 sec. at 1/2" dia. Reach time for heavy friction was only slightly (about 0.01 sec.) greater than for moderate friction. Turning time versus diameter produced a U shaped function for both friction values although the moderate friction curve was much flatter. End and minimum points as follows:

	Turning Time(sec)	
Knob Dia. (in.)	Moderate Friction	Heavy Friction
1/2	1.19	1.68
1-3/4	0.84 (minimum)	----
2	----	0.87 (minimum)
3-1/4	0.92	1.00

Reference: After Bradley and Arginteanu (1956).

Item: Rotary 17

Task: Reach and adjust one of a set of concentric knobs to extinguish the stimulus light.

Stimulus: A single amber light turned on by E.

Subjects: 76 male college students including both left and right handed.

Response Mechanism: Up to three concentric knobs mounted on a vertical panel in front of S. Knob diameter and thickness controlled as experimental variables. A black index line aided adjustment of operated knob. Standard setting was about 125^{o} displacement to 2^{o} adjustment zone at which point the index line was pointing up.

Conditions: Nine separate but related experiments involving a variety of conditions pertaining to shielded and unshielded concentric knobs.

S used dominant hand in making adjustments.

S kept operating hand on telegraph key until stimulus onset.

Reach time measured from release of key until operated knob began to turn. Turning time measured from end of reach to completion of adjustment.

S instructed to work as fast and accurately as possible but to avoid touchi any knob other than the one to be adjusted.

Touching errors were measured with a maximum of one back knob error and one front knob error per trial.

(Differences in sensitivity of thyratron touch circuits precluded

comparisons of "front" and "back" touching error rates.) CW and CCW adjustments were alternated.

Results: On the basis of all experiments it was determined that the front and middle knobs should be 3/4" thick, the back knob at least 1/4" thick; the middle knob between 1-1/2" and 2-1/2 dia., the front knob 1" smaller in dia. than the middle, and the back knob 1-1/4" larger in dia. than the middle. Average performance data for such a set of knobs would be as follows:

Knob operated	Reach time (seconds)	Turn time (seconds)
Front	.56	1.43
Middle	.62	1.37
Back	.61	1.27

Reference: After Bradley and Stump 1955 (b).

Item:	Rotary 18
Task:	Make blind adjustment (angular bisecting) with a rotary knob.
Stimulus:	None
Subjects:	20 male college students and 80 young military men.
Response Mechanism:	A rotary knob, 2.5" dia. mounted on a vertical surface in front of S. Shaft friction and angle to be bisected controlled as experimental variables.
Conditions:	S wore opaque goggles. S sampled the angle twice before bisecting. 5 values of friction: 0.01, 2.24, 4.16, 6.69, and 8.71 ft. lbs. 4 angles: 40, 80, 120, and 160 degrees. Two experiments, one with each subject group. In college group all Ss performed under all variable combinations whereas in the military group each subject performed on only one friction value. Both groups made 10 settings per condition, after 2 or 4 practice settings. Setting values recorded by E. S not informed how well he was doing.
Results:	Friction did not influence mean accuracy of settings but variance increased with increasing friction. No noticeable trend with size of angle to be bisected. Average error based on all conditions and both experiments was about 11% (σ =20%) of 1/2 angle to be bisected.
Reference:	After Swartz et al.

Item: Rotary 19

Task: Make blind adjustment (angular bisecting) with a rotary control knob.

Stimulus: None

Subjects: 96 right handed military men.

Response Mechanism: A smooth plastic knob 2.5" in diameter mounted on a vertical surface in front of S.

Conditions: Three angles: 40°, 80°, and 120°.

S sampled angle twice before bisecting. Direction of final adjustment alternated between CW and CCW.

S made 20 settings with an 80° angle and 16 each with 40° and 120°.

Mechanical stops used to establish angle to be bisected.

E recorded settings from 8" dia. calibrated scale.

S not given knowledge of results.

Results: All setting mean errors were positive indicating a tendency to overshoot the correct value.

A decrease in accuracy with increasing trials was present on the 40° and 80° angles.

Mean error ranged from 1% to 18% (percent of 1/2 angle to be bisected) on the first trial to 10% to 38% on the 8th trial.

Reference: After Green (1955).

Item: Rotary 20

Task: Make blind adjustment (angular bisecting or duplicating) with rotary control knob.

Stimulus: None

Subjects: Twelve right-handed paid male college students.

Response Mechanism: A smooth plastic knob 2-1/2" dia. Plane of rotarion controlled as experimental variable.

Conditions: Four angles: 20°, 40°, 80°, and 160° defined by mechanical stops.

Three planes of rotation: front, side, and top.

Two tasks, bisecting or duplicating sampled angle.

S sampled angle twice before bisecting or duplicating.

All settings made in CW direction.

E removed one stop after sampling to permit duplication of the sampled angle.

S wore opaque goggles.

S made a total of 20 settings for each of the 24 variable combinations.

S was not told how well he was doing.

E recorded settings from a calibrated dial.

Results: Plane of rotation had no significant effect on accuracy.

Percent error decreased, for both tasks, with an increase in the angle size. Bisecting errors ranged 25% to 10%

duplicating errors from 18% to -3%. (Bisecting error based on percentage of 1/2 angle to be bisected.)

All errors were positive, except when duplicating 80° or 160°, indicating a tendency to overshoot the correct value.

Reference: After Davidson et al (1953) (Experiment I).

Item: Rotary 21

Task: Make blind adjustment (angular bisecting) with a rotary control

Stimulus: None

Subjects: 16 right-handed paid male-college students.

Response Mechanism: A smooth control knob mounted on a vertical surface in front of S. Knob diameter controlled as experimental variable. Mechanical stops designated angle limits.

Conditions: Eight knob diameters ranging from 1/2" to 5".

Four angles to be bisected 40°, 80°, 120°, and 160°.

Each S made 15 bisections (5 practice, 10 recorded) on each combination of conditions.

E recorded settings from calibrated disk

S wore opaque goggles.

S sampled angle twice, then made setting in CW direction.

Results: All errors were positive indicating a tendency to overshoot the correct value.

Percent error (% of 1/2 angle to be bisected) decreased with increasing diameter from 30% at 1/2" to 21% at 2" and remained approximately constant thereafter.

Percent error decreased with increasing angle size from 32% at 40° to 18% at 160°.

Reference: After Davidson et al (1953 Experiment II).

Item:	Rotary 22
Task:	Adjust rotary knob to turn out stimulus light.
Stimulus:	A neon light which went out when control was within adjustment zone.
Subjects:	36 right-handed
Response Mechanism:	A flat circular knob geared to a potentiometer. Knob diameter and orientation controlled as experimental variables. Shaft torque "low". Standard displacement of about 2-1/4 revolutions into 4.5° zone required to turn out light.
Conditions:	Three knob diameters; 1/4", 3/4", and 2". Three knob plane orientations; frontal, flat (top), and right side. Travel time measured from initial movement of knob until first entry into adjustment zone. (S usually overshot zone.) Adjustment time measured from end of travel time until control came to rest in adjustment zone. Each S made twenty settings on one of the nine conditions.
Results:	No statistically significant differences were demonstrated. Average travel time ranged from 1.86 sec to 3.41 sec (M=2.67 sec) Average adjustment time ranged from .36 sec to .76 sec (M=.57 sec)
Reference:	After Stump 1953.

Item: Rotary 23 (See PB 24)

Item:	Rotary 24
Task:	Adjust a pointer on a linear scale
Stimulus:	A horizontal scale 3/4" by 11" with a vertical hairline scribed in the center and a lucite pointer also with a vertical hairline.
Subjects:	12 right-handed
Response Mechanism:	A rotary control knob 2-3/4" dia. located in a "convenient" position. The knob shaft was connected to the pointer through a ball-disk integrator permitting adjustment of the D/C ratio and a magnetic clutch which permitted E to stop a trial.
Conditions:	S required to set pointer hairline over scale hairline as rapidly and accurately as possible using right hand. Four initial positions of the pointer; 15/16" left and right of center and 50/16" left and right of center. S required to make settings within allotted time. Twelve time intervals tested in decreasing order from 4.0 to 0.4 sec. Three D/C ratios tested, 1", 2", and 4" of pointer movement per revolution of the control knob. Stimulus hidden from S by shutter until beginning of trial. Three time measurements were made; (1) total time from beginning to end of trial, (2) travel time from beginning of trial until pointer was within 0.1" of the target, and (3) adjustment time from end of travel time until S was satisfied

with alignment or trial was termined by E on the basis of allotted time. S operated a switch to end trial. S made 144 settings involving all allotted time intervals (in sequence), all initial positions (in random order), and one D/C ratio in each of 1 practice and 9 experimental sessions. D/C ratio changed between sessions.

Results: Mean error for long allotted times was about 0.0025" and increased rapidly below about 2 seconds of allotted time. This critical time point varied slightly with initial pointer displacement, from about 1.8 sec for short distance to 2.4 sec for long distance.

Travel time was dependent upon distance and for long distance also upon D/C ratio; 0.6 sec for short travel and 1.2 to 0.9 sec. vs increasing D/C ratio for long travel.

Adjustment time varied slightly with distance and D/C ratio; about 1.0 to 1.1 sec vs D/C ratio for short travel and about 1.1 to 1.2 sec. vs D/C ratio for long travel.

Reference: After Greek and Small, Jr. (1958).

Item: Rotary 25

Task: Bisect an angle with a rotary control.

Stimulus: None

Subjects: 12 paid right-handed male students

Response Mechanism: A smooth knob 2-1/2" dia. by 5/8" thick mounted on a horizontal shaft. Nature of end point cues controlled as experimental variables.

Conditions: Three types of end point cues; tactual, visual, and auditory. Four sizes of angle to be bisected; 20°, 40°, 80°, and 160°. S prevented from viewing his hand or knob while bisecting. S sampled angle twice before bisecting in a clockwise direction.

Counterbalanced design with each S making 20 settings at each combination of end point cue and angle size.

Results: All mean errors were positive in dialing S turned knob too far. Error data suggests performance was better with auditory cues and poorer with visual cues but this trend was not statistically significant.

Mean absolute errors increased (2.5° to 8.8°) with increase in size of angle to be bisected but percent (of half angle) error decreased (25% to 11%). Standard deviations were about 75% to 130% of the error scores.

Reference: After Spragg and Devoe (1956).

Item: Thumbwheel 1

Task: Change setting on a thumbwheel switch

Stimulus: Verbal command to change setting from 2 to 4 or from 4 to 2.

Subjects: 76 male and 14 female college students with no previous experience on thumbwheel switches.

Response Mechanism: Chicago Dynamics type TMD; (wheel type, 1-3/4" dia. by 1/4" wide) with odd numbers masked. Switch mounted in the center of a 45° sloped panel about 5" above a 31" high disk in front of seated subject. Two switches used, one increased for upward movement the other increased for downward movement.

Conditions: S's told that purpose of study was to determine how rapidly people could operate this type of switch.
Actual main interest was direction of turn population sterotype. Half of S's instructed to turn from 2 to 4 and the other half from 4 to 2. Also about half of S's in each of these two groups worked with one switch while the remainder worked with the opposite switch. Apparently one trial per S.
Time, to reach from point 5" below switch and complete adjustment, measured with stopwatch.

Results: Direction of initial movement observations indicated no population sterotype. Authors recommend upward-to-increase be established as a standard since control aspect outweighs

display aspect.

Mean setting time as follows:

Initial movement correct (2 steps)	- 2.78 sec	(N-47)
Initial movement incorrect but S reversed direction	- 4.18 sec	(N-13)
Initial movement incorrect and S continued long way around (8 steps)	- 4.97 sec	(N=30)

Reference: After Wade and Cohen (1962)

Item:	Cursor 1
Task:	Designate simulated targets with a small joystick controlling the position of a light beam.
Stimulus:	Circular apertures on a white painted surface.
Subjects:	10, highly trained
Response Mechanism:	A small joystick about the size of a mechanical pencil which positioned a light beam by means of mirrors. Two to four ounces of friction loading added for parts of the experiment; otherwise, control resistance negligible. C/D ratio controlled as experimental variable.
Conditions:	Three target aperture sizes, 1/8", 1/4", and 1/2", related to accuracy requirement. Two joystick resistances, with and without 2 to 4 ounces of friction. Four hand support conditions; none, elbow support, heel of hand support, or pencil grip on joystick. Seven C/D ratios 1/5, 1/5.6, 1/10, 1/11, 1/23, 1/35, 1/44. Four handle lengths, 2+", 5+", 11+", 19". Several parts to study, usually 4 <u>S</u>s per part making 24 settings each (8 per aperture size).
Results:	The small amount of friction was indispensable for precise designation. Hand support provided better performance than other support conditions. Speed of designation varied inversely with size of target apertures and inversely with C/D ratio. At 1/8" aperture and 1/35 C/D ratio mean

designation time was 4.2 seconds, for 1/2" aperture and 1/5 C/D ratio 1.4 seconds was required. Both of above values with 2-4 oz. friction, but without hand support. Error rate (missed target) ranged from 0 to 7% with poorest performance corresponding to slowest speed.

Reference: Reed (date unknown)

Item: Cursor 2

Task: Designate (hook) tracts on a radar scope with various types of controllers.

Stimulus: Patterns of 4 to 12 simulated target tracks on a 10" radar scope.

Subjects: 1 to 13 depending upon part of study.

Response Mechanism: The following specific devices were evaluated: Bell Telephone Labs (BTL) pantograph, Naval Research Labs (NRL) pantograph, Navy Electronics Lab. (NEL) joystick (with and without pencil attachment), Rolling ball with air bearing, Raytheon joystick with viscous damping, range and bearing cranks, Telautograph (TA) pantograph, XY slider control and conducting glass overlay (CGO) with voltage probe pencil.

Conditions: Four separate, but related, experiments: Direct tracking with enforced accuracy, Direct tracking without enforced accuracy; Mockup comparison of CGO and BTL pantograph, and differential tracking study.

All controllers were not evaluated in each experiment. Under forced accuracy conditions, Ss could tell when they made an error. Required accuracy was ± 1° in bearing and ± 1 mi. in range. Cursor was 1/8" diameter circle for all devices except range and bearing cranks which used radial line and hash mark.

Ss practiced on each controller before trials. Accuracy measured by two techniques: during trials by a scoring judge, and after trials by analysis of scope photographs.

Results: Direct tracking with enforced accuracy:

CONTROLLER	Speed *Mean Targets per min.	Percent Measured errors	percent judged errors	Fatiguing + Effect
NRL Pantograph	42.7	26	9	5
BTL Pantograph	43.0	13	7	4
NEL Pencil joystick	38.4	18	6	2
NEL joystick	34.2	26	20	3
Raytheon joystick	28.2	17	7	6
Rolling ball	27.3	16	5	1
Range and Bearing cranks	22.9	17	1	7

*Data combined across target densities of 6, 8, 10 and 12. Maximum possible rate 48.0

+Operator's subjective judgements. Rank 1 = least fatigue effect.

Direct tracking without enforced accuracy:

CONTROLLER	Percent Targets hooked out of 1000 for all densities
NEL joystick	95
TA pantograph	93
NRL pantograph	91

CONTROLLER	Percent Targets hooked out of 1000 for all densities
XT Slider control	71
CGO	43*

*The CGO used in the study had equipment difficulties probably resulting in abnormally poor performance.

Mock-up comparison of CGO and BTL Pantograph:

CONTROLLER	Speed Targets per min.
CGO	140
BTL Pantograph	134

Differential Tracking:

CONTROLLER	Speed, Targets per min.	Measured Error rate	Judged Error rate
Rolling Ball	44	21%	4%
NEL pencil joystick	49	24%	4%

Reference: After Hedlun and Coburn (1955)

Item: Cursor 3

Task: Establish tracking gates on simulated radar targets with joystick controllers.

Stimulus: 12 simulated radar targets moving in a variety of headings at speeds of mach 1 and lower.

Subjects: Three experienced airmen operators.

Response Mechanism: Three joysticks, all self-centering with slewing buttons, differing as follows: standard length-single speed slewing
standard length-double speed slewing
short stick-double speed slewing

Conditions: The subjects made a total of 2800 gate assignments after practice. Two speed scores made: (1) time required to gate all 12 targets and (2) number gated within 30 seconds. The error score was number of targets lost one minute after completion of gating.

Results:	Standard-1 Speed	Standard-2 Speed	Short-2 Speed
No. gated in 30 sec.	424	417	416
Errors 1 min. later	7	19	21
Time(min.) to assign 12	0.51	0.64	0.62
Errors 1 min. later	5	17	22

Reference: After Sulzer and Cameron (1959).

Item:	Cursor 4
Task:	Tag simulated radar targets using a joysphere (rolling ball).
Stimulus:	One of nine stationary targets presented sequentially on the screen of dual beam CRT. Target locations arranged symmetrically around the tracking area.
Subjects:	Seven right-handed males
Response Mechanism:	A ball 4-1/2" dia. supported by a bowl containing smaller bearing balls. X-Y position sensors driven by wheels in contact with the ball. The ball was located in the table top in front of S.
Conditions:	Three C/D ratios - 1/4:1, 1:1, and 10:1. Two tracking area sizes - 1/2"x1/2" and 2"x2". Two hand conditions: preferred and nonpreferred. The ball could be located either on the left or right side of the table. S required to press a "correction bar" with opposite hand after positioning tracking pip over the stationary target. This action also caused the target location to change, thus a self-pacing task. Each S performed twice under each condition of ratio and area with 100 targets per condition run. S had 100 practice trials prior to experimental runs. Hand conditions tested with 4 Ss on ratios of 1:1 and area of 2"x2".
Results:	Very little difference in speed and accuracy versus C/D

ratio. Average time per target on smaller area was about 1.9 sec, (σ 0.2), on the larger area about 2.2 sec (σ 0.2). Error (based on linear distance between target and tracking pips at time correction bar was pressed) about 0.01" for both areas. Small decrement in performance with nonpreferred hand.

Reference: After Doughty (1958).

Item:	Cursor 5
Task:	Tag simulated radar targets using a joystick or rolling-ball.
Stimulus:	One of 25 stationary targets presented sequentially on a 12" CRT mounted at 30° from vertical. Target locations random within stimulus area. Target pip 1 mm in dia. Strobe was circular ring 3 mm in dia.
Subjects:	24 experienced radar operators (6 male, 18 female.)
Response Mechanism:	Two devices tested, a joystick and a rolling ball. The joystick consisted of a 6" stick with a C/D ratio of 90° stick displacement per 10" of strobe displacement. The rolling ball was a 5" dia. ball mounted on an air bearing with contacting wheels for data pickoff and a C/D ratio of 1 revolution per 2-1/2" of strobe displacement. Strobe movement was compatible with control movement for both devices and they were mounted in a horizontal surface in front of S.
Conditions:	Two devices as described. Three stimulus areas: 2.8 cm. sq., 7 cm. sq., and 11 cm. sq. Correction distances (from one target to the next) ranged from less than 5 mm to full diagonal of stimulus area. S required to press a button when strobe was over the target. This also changed location of target, thus a self-pacing task. S informed of accuracy criteria, target could be anywhere within strobe when button was pressed. Trial scored as

error if this condition not met.

S received 6 minutes practice with each controller on a different stimulus set.

Each S had 2 runs of 25 targets each per condition in a balanced design.

Results: Classified Canadian report.

Reference: After Thornton (1954)

Item:	Cursor 6
Task:	Capture (tag) a simulated radar target using a joystick.
Stimulus:	A sequence of targets randomly positioned on a 3" dia. circle in the center of a 21 inch CRT. The target was a spot 0.02" dia. at a brightness of about 40 ft. L. The cursor was an annulus 0.05" thick with a 0.15" inside diameter and brightness of 25 ft. L.
Subjects:	Five male engineers experienced on the type of task.
Response Mechanism:	A self-centering positional joystick 4.5" long with a 1/2" dia. ball all on the end of a 5/16" dia. shaft. Operating force: 9 oz. at 1" tip displacement, 27 oz. at 3" max. tip displacement. Joystick mounted vertically in right arm of S's chair. C/D ratio controlled as experimental variable.
Conditions:	5 C/D ratios (joystick tip movement to cursor movement) 2.00, 1.00, 0.25, 0.125, 0.0625. 4 accuracy requirement conditions: 0.01", 0.02", 0.04" and 0.08". Two procedure/pacing conditions investigated in separate experiments. In 1st experiment S required to hold cursor on target with required accuracy for 0.5 second after which target would automatically return to center then after 3 sec. delay go to new position. In 2nd experiment S required to press a button with left hand when he thought cursor was on target. E called out "hit" or "miss". In experiment I each

S tested under all condition combinations with 10 practice and 30 experimental trials per combination. Experiment II used only 0.01" and 0.04" accuracies but all C/D ratios, again 10 practice and 30 experimental trials per S.

Results: In experiment I speed of target capture ranged from a minimum of 2 seconds per target at C/D ratio of 2.0 and 0.08" accuracy to an impossible task at the greater accuracies and lower C/D ratios. Performance in experiment II was somewhat better, especially at the 0.01" accuracy and 0.0625 C/D ratio where median capture time was 12 sec. with 22% of the captures "hits".

A single condition, 0.01" accuracy and 2.0 C/D ratio, was tested with the self-centering feature removed from the joystick using the same Ss. Results were very close, slightly better, to those of Experiment II for the same conditions suggesting that spring force is not as important as C/D ratio and required accuracy.

Reference: After Carel and Minty (1959).

Item: Cursor 7

Task: Capture a simulated radar target using a joystick and rolling ball.

Stimulus: A sequence of targets (presented one at a time) located randomly on a 12" dia. circle centered on a 21" CRT. Target was a 1/4" blip. Cursor was a 1/2" dia. circular ring.

Subjects: Two groups of 12 and 6 male and female laboratory personnel.

Response Mechanism: The rolling ball was a 4-1/2" dia. duck pin ball mounted on an air bearing using magnetic data pickoff with read heads in contact with the ball. The joystick had a maximum total displacement of 90°. C/D ratios for both devices controlled as experimental variables.

Conditions: Two experiments, one with each controller.

Four C/D ratios for rolling ball (deg/inch) of 10, 21, 41, and 85.

Three C/D ratios for joystick (deg/inch) of 1, 4, and 7.

Each S in a group made at least 30 responses under each C/D ratio.

When S "captured" target machine would return both target and cursor to center of scope. A perfectly centered target would return to center slightly sooner than one imperfectly centered.

Results:

Control	C/D ratio (deg/inch)	Capture Time (sec)	σ (sec)
Joystick	1	3.05	2.85

Joystick	4	2.04	1.55
Joystick	7	2.03	1.58
Rolling Ball	10	3.96	1.32
Rolling Ball	21	3.59	1.14
Rolling Ball	41	3.31	0.66
Rolling Ball	85.	3.57	0.71

Another experiment in the series explored rolling ball C/D ratios up to 3600. Capture time increased rapidly to 11.7 sec. at the C/D ratio of 3600.

Reference: After Anon, "The Bowling Ball Cursor Control", GE (1960).

Item:	**Cursor 8**
Task:	**Tag a simulated target with a joystick controller.**
Stimulus:	**A simulated scope face consisting of a vertical 12" dia. metal disk containing seven 1/4" dia. lucite inserts on a 10" dia., six inserts on a 7" dia., and four inserts on a 3" dia. Each disk capable of illumination thus simulating stationary targets. The cursor was a .150" dia. metal disk.**
Subjects:	**Three groups consisting of 19, 17, and 10.**
Response Mechanism:	**A large joystick located between Ss knees. Cursor was mechanically connected to joystick through a hydraulic cylinder on the Y axis and a Prony brake on the X axis. Joystick length and C/D ratio controlled as experimental variables.**
Conditions:	**One target (lucite disk) illuminated at a time by E. S required to press a button when cursor centered over target. This stopped time clock and operated scoring mechanism. Trial scored as miss if cursor touched metal when pressed against target disk.** **Three experiments:** **1st - Four lever lengths of 12, 18, 24, and 30 inches Three C/D ratios (stick tip movement to cursor movement) of 2.0, 2.5, and 3.0.** **S operated button with hand opposite that controlling joystick. Cursor movement compatible with stick movement.**

Each of 19 Ss made 20 settings at each of 10 positions at each length-ratio combination (except 12" with ratio 3 not tested).

2nd - Two S/R compatibility conditions. Y axis normal and reversed. Five C/D ratios of 1.4, 1.9, 2.2, 2.5, and 3.0.

S operated button with hand opposite that controlling joystick.

Each of 17 Ss made a total of 20 settings with normal movement and 40 settings with reversed movement at each of 10 positions for each ratio.

3rd - Three button operation conditions; opposite hand, same hand (button on end of lever), and foot switch.

C/D ratio of 2.5

Stick length of 24"

Normal Y axis movement.

Each of 10 Ss made 30 settings at each of 17 positions for each switch operation condition.

Results: The first experiment showed little difference in performance versus either stick length or C/D ratio. Mean setting time was slightly less for length of 24" and ratios of 2.5 and 3.0. Errors were slightly less at ratio of 3.0. Overall average setting time 1.6 sec (σ 0.3 sec). Overall average error 2%. The second experiment showed performance with Y axis reversed improved with practice but was inferior to the normal condition. Best C/D ratio was 2.5 with mean setting time

1.56 sec (σ 0.31) and error of 4.8%.

The third experiment showed no difference in setting time versus switch operation conditions ($\bar{M}$ = 1.47 sec., σ 0.19) but a difference in error rate, 8.9% for "other hand", 10.1% for joystick tip, and 8.2% for switch.

Reference: After Jenkins and Karr (1954).

Item:	Cursor 9
Task:	Tag simulated radar targets with a free-moving stylus (pencil probe).
Stimulus:	A 11" dia. metal disk containing 48 randomly located 1/16" dia. holes back lighted. A semicircle revolving at 6 rpm permitted illumination of 24 holes (simulated targets) at a time. The outer disk rotated once per 13 min, 42 sec. simulating target action. Display ambient 0.1 ft. candle.
Subjects:	30 experienced radar operators (24 female, 6 male).
Response Mechanism:	A plastic stylus 6" long by 1/2" dia. with a metal tip less than 1/16" dia. A flexible wire was attached to the opposite end of the stylus.
Conditions:	Ss instructed to work for accuracy rather than speed. S instructed to touch stylus to pip firmly and operate a switch with the opposite hand. Trial scored as an error if the stylus was touching the metal disk rather than the pip. S given two 2 minute practice sessions followed by one 30 minute experimental session. Speed and error scores recorded at 1 minute intervals.
Results:	Classified Canadian report.
Reference:	After Baker et al (1954).

Item: Cursor 10

Task: Tag simulated radar targets with a free-moving stylus (pencil probe).

Stimulus: A 12" dia. CRT inclined 30° from vertical with 25 target pips appearing one at a time in random location within an area whose size was controlled as an experimental variable.

Subjects: 12 naive

Response Mechanism: A stylus (by reference assumed to be plastic 6" long by 1/2" dia with 2-1/16" dia metal tip.)

Conditions: Two target areas; 2.8 cm. sq. and 7 cm. sq.

One minute practice prior to experimental runs.

Each S performed for 5 min. on each area size.

S required to press button with opposite hand when stylus over target. This action caused target location to change, thus self paced task.

Errors not recorded

Results: Classified Canadian report

Reference: After Addendum to Baker et al (1954).

Item:	Cursor 11
Task:	Push a button while performing a compensatory tracking task with a self-centering positional joystick.
Stimulus:	A spot of light on a CRT capable of movement in two directions for the tracking task and a buzzer at 12 second intervals for the button pressing task.
Subjects:	12 adult males
Response Mechanism:	A self-centering 2-dimensional positional joystick with 14° displacement from center. Stick length was 4.5" long with a 1" diameter spherical knob on the top. Two buttons used; one on top of the joystick knob with an operating force of 35 oz. and the other a foot switch.
Conditions:	Four experiment conditions; finger pushbutton with and without forearm support for S's controlling arm and foot pushbutton with and without forearm support. S required to keep spot within 0.1" dia. circle with slow random forcing functions on each axis. Each S practiced without pushbutton operation until he could track accurately for periods of several seconds at a time. Each S operated button 12 times under each condition in latin square design.
Results:	Results expressed as amount of peak angular disturbance immediately following button pressing. Mean peak disturbances

as follows:

Condition	Mean (minutes of arc)
Finger; arm support	44
Foot; arm support	6
Finger; no support	45
Foot; no support	9

Reference: After Gibbs and Bilney (1955).

APPENDIX III

EXPERIMENT ON HUMAN PERFORMANCE WITH SEVERAL DEVICE TYPES AND NUMBER OF RESPONSE ALTERNATIVES

INTRODUCTION

In the context of command and control systems, human operators are frequently required to initiate communications (i.e., input data or instructions) to a digital computer complex. For on-line operators, a relatively routine task is that of selecting one of several alternatives. A frequently used mechanism for this manual input function is a matrix of switch devices. In the design of these matrices, questions frequently arise on the relative utility of the several available switch devices and on the relation between matrix size and operator performance. This experiment was undertaken as an initial step in the collection of a complete set of empirical data establishing human performance as a function of number of response alternatives and response mechanism. Specifically, data were collected on the speed and accuracy of subjects in selecting and completing a response from 1, 2, 4, 7, and 10 alternative response possibilities, represented by the appropriate number of pushbutton, toggle, rocker, and slide switches. In addition, the experimental data have been combined by several composite scoring procedures, including information transmission rate, in order to explore their effect on conclusions that might be drawn regarding the superiority of one type of device over another.

APPARATUS

The experimental apparatus consisted of a set of four switch panels and a stimulus panel at the subject's position, and an automatic random delay generator, time clock, and control panel at the experimenter's position. One switch panel at a time was mounted in front of the seated subject at a slope of 18° from the vertical as shown in the drawing of the subject's position, Figure III-1. Ten switches of one type were mounted in a horizontal row on 1" centers on each panel with the long dimension of the switches oriented vertically. Direction of movement was down for the toggles and slides, downward and in for the rockers, and in for the pushbuttons. A sketch of each type of switch studied is shown in Figure III-2. All switches were momentary action and returned to the "off" position when released by the subject. The switches selected for the experiment are all commercially available and as representative of their class as a single switch can be. Mean operating forces for the switches were as follows: Rockers, 2.05 lb; pushbuttons, 2.03 lb; toggles, 1.98 lb; and slides, 1.58 lb. Switch labels consisting of 9/16" high white capital letters on a black background were placed immediately above the row of switches on each switch panel. Thus the -1- switch case had the label "E" associated with the switch; the -2- switch case had "E" and "F"; t' ` -4- switch, "D", "E", "F", "G"; the -7- switch, "C" through "J", with "I" omitted; and the -10- switch, "A" through "K", with "I" omitted. The stimulus was presented by means of an Industrial Electronics Engineers series 10,000 projection display mounted above the switch panel. This device back projected 1" high white capital letters on a dark background. Stimulus and label letter fonts were identical.

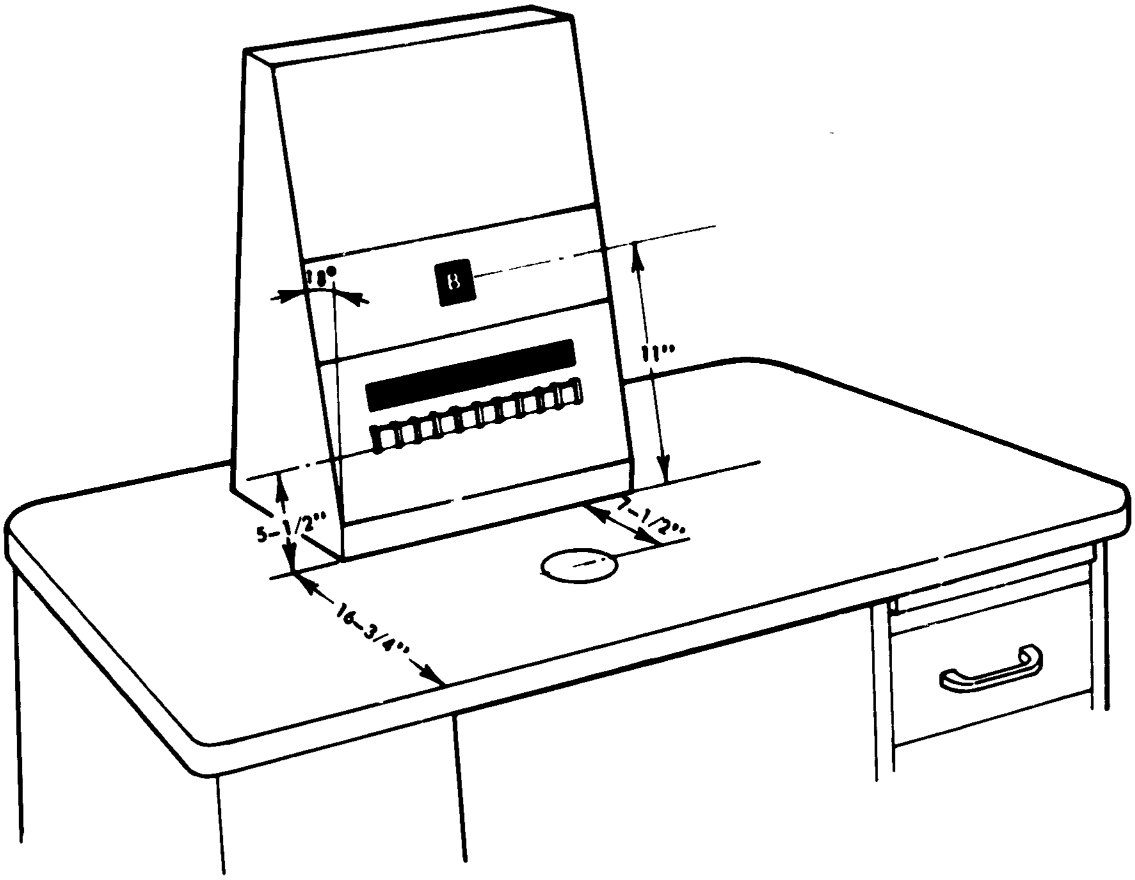


Figure III-1 Subject Station

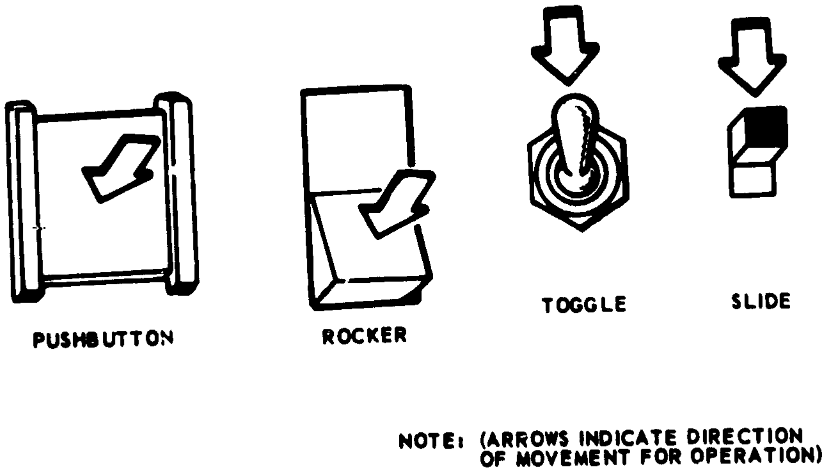


Figure III-2 Switches Tested

The experimenter's control panel consisted of a 10-position rotary selector switch to select the stimulus letter and a row of 10 indicator lights to show which switch was activated by the subject. The experimenter was also provided with a hand-held pushbutton switch with which to initiate the stimulus presentation sequence. Closing this switch triggered a time-delay mechanism which turned on the selected stimulus and simultaneously started the time clock after a randomly varying interval of from 1 to 4 seconds. Actuation of any switch by the subject stopped the time clock, turned off the stimulus, and reset the time delay mechanism.

PROCEDURE

The subject sat in front of the switch panel with his right hand resting on a starting position indicated by a red dot on the table surface in front of the switch panel (see Figure III-1). He was instructed that a letter would appear on the display screen from 1 to 4 seconds after the experimenter announced "Ready", and that his task was to locate and operate the switch with the corresponding label as rapidly and accurately as possible with his right index finger and to hold the switch until the experimenter announced "Release". This latter requirement was imposed to permit the experimenter to detect errors, and to discourage the subject from taking ballistic swipes at the switch. The experimenter used a prepared schedule to select the successive stimuli. Sixteen different schedules were parpared using a

table of random numbers, a different schedule for each combination of alternatives (except the one-switches simple reaction case) and switch type. Thus, each subject encountered a given order of stimuli only once.

A factorial design was used with each of four right-handed male subjects operating under each of the 20 experimental conditions. All alternative conditions for a given device were presented in a single session of about 1-1/4 hours duration, including rest periods. Order of presentation of devices and alternatives within devices was counterbalanced across subjects except that the simple reaction condition was always presented last in a session. Each subject received 10 practice trials at the beginning of each session. The number of experimental trials was varied in accordance with the number of alternatives as follows:

Alternatives	Trials Per Sessions
1	20
2	20
4	40
7	70
10	100

The switch group and associated labels used for a given alternative condition was identical for all devices and subjects. Masks were placed at the ends of the array covering both labels and switches, to make the number of available alternative switches obvious to the subject. Within each stimulus schedule, each stimulus letter appeared an equal number of times.

Response time from onset of stimulus to activation of any switch was measured by an electric stop clock and manually recorded to the nearest 0.005 second increment. The first switch activated by the subject was monitored and recorded by the experimenter. Touching errors were not monitored, nor was any credit given if the subject noted and corrected an incorrect response.

RESULTS

The semi-reduced response time data are presented in Table III-1 categorized by device, number of response alternatives and subject. The table entries are mean seconds, based on trials of N=20 for all 1-alternative cells, N=20 for all 2-alternative cells, N-40 for all 4-alternative cells, N-70 for all 2-alternative cells, N=100 for all 10 alternative cells. Figure III-3 shows these data summarized by both trials and subjects. As expected, response time shows an orderly growth as the task complexity, i.e., number of stimulus-response alternatives, increased. Note also the rather regular differences in performance time associated with the different device types. Table III-2 shows the results of an analysis of variance of the response time data given in Table III-1. Note that the primary variances sources, subjects, devices and alternatives, are all highly significant, while none of the first order interactions are, i.e., P is greater than 5%.

The observed variability in performance is also of interest. The standard deviations for each of the subject, device and alternatives combinations are given in Table III-3. These variability data are plotted

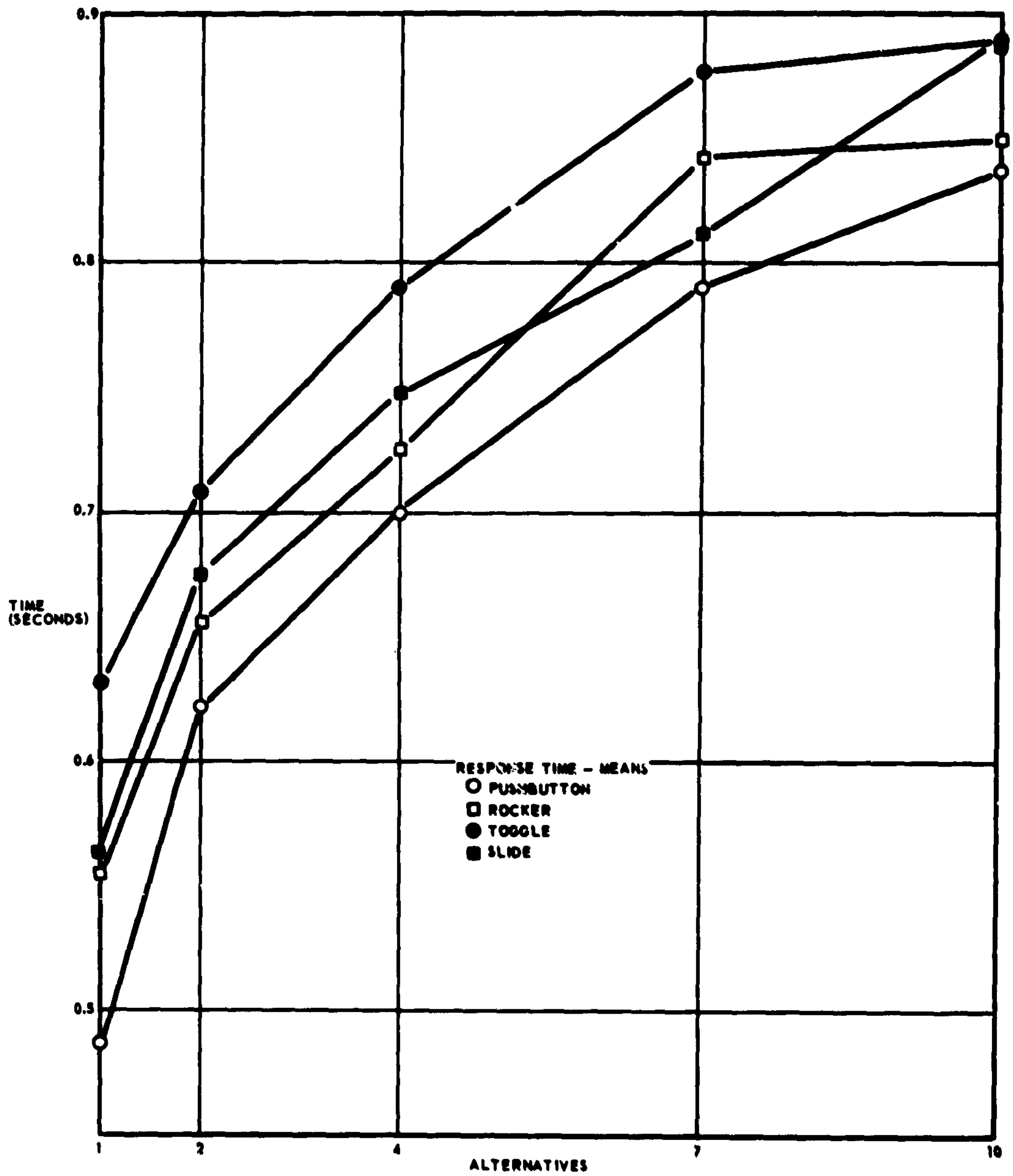


Figure III-3 Mean Response Time

TABLE III-1

RESPONSE TIME DATA (SECONDS)

Device Alternatives		Pushbutton					Toggle					Rocker					Slide				
		1	2	4	7	10	1	2	4	7	10	1	2	4	7	10	1	2	4	7	10
	S_1	.489	.564	.677	.779	.844	.576	.694	.794	.882	.881	.563	.746	.678	.867	.792	.487	.633	.687	.785	.899
Subjects:	S_2	.568	.757	.842	.853	.938	.709	.810	.881	.981	.969	.657	.658	.791	.884	.904	.652	.749	.879	.912	.943
	S_3	.475	.650	.681	.830	.844	.649	.686	.758	.850	.902	.566	.674	.747	.883	.921	.581	.718	.779	.837	.921
	S_4	.410	.513	.598	.700	.721	.586	.643	.728	.794	.804	.430	.555	.682	.731	.775	.530	.597	.646	.707	.791

TABLE III-2

RESPONSE TIME ANALYSIS

Variance Source	df	Variance Estimate
Between Devices	3	.0288*
Between Alternatives	4	.2486*
Between Subjects	3	.0995*
Interaction: Devices X Alternatives	12	.0012
Interaction: Devices X Subject	9	.0023
Interaction: Alternatives X Subjects	12	.0009
Residual	36	.0012
Total	79	--

* Significant at the .1% level

TABLE III-3

RESPONSE TIME VARIABILITY -- STANDARD DEVIATIONS (SECONDS)

Device Alternatives	Pushbutton					Toggle					Rocker					Slide				
	1	2	4	7	10	1	2	4	7	10	1	2	4	7	10	1	2	4	7	10
S_1	.092	.065	.098	.112	.142	.103	.109	.105	.164	.138	.170	.108	.104	.135	.122	.057	.030	.136	.120	.144
Subjects: S_2	.094	.057	.099	.104	.129	.079	.129	.101	.128	.143	.065	.059	.086	.132	.142	.034	.080	.138	.131	.112
S_3	.096	.109	.052	.080	.099	.187	.109	.118	.101	.126	.114	.103	.101	.110	.119	.031	.095	.068	.100	.130
S_4	.059	.027	.042	.079	.078	.098	.052	.143	.105	.108	.040	.074	.113	.077	.120	.111	.057	.058	.087	.118

in Figure III-4. Each of the plotted points is the arithmetic mean of the four standard deviations from the four subjects. Note the general increase in performance variability as task complexity (number of alternatives) increases, except for the inflection in the case of three of the device functions at the 2-alternatives condition. This inflection probably results from the behavior transition from a simple reaction, concentration on speed task (1-alternative), to a choice reaction, requirement for accuracy task (2 or more-alternatives). The failure of the slide switch function to show that transition is probably due to the construction of the specific type of slide switch used. Each of the subjects commented on the painful results of not carefully placing the actuating finger on the slide switch. Rather sharp corners on the switch had to be avoided resulting in a considerably more deliberate response than with the three other device types.

As usual in tasks of this sort, errors were very rare. Of the 4000 total responses in the experiment, only 39 (.98%) were in error. The distribution of those errors by subject, device and number of alternatives is given in Table III-4. On the qualitative side, thirty-eight of the errors involved operation of the switch adjacent (right or left, about equally divided) to the correct switch. The one exception was operation of a switch two places removed from the correct one.

While the small number of errors prevent any sophisticated analysis, several qualitative observations on the relation between the speed and accuracy measures are of interest. The order of subjects with respect

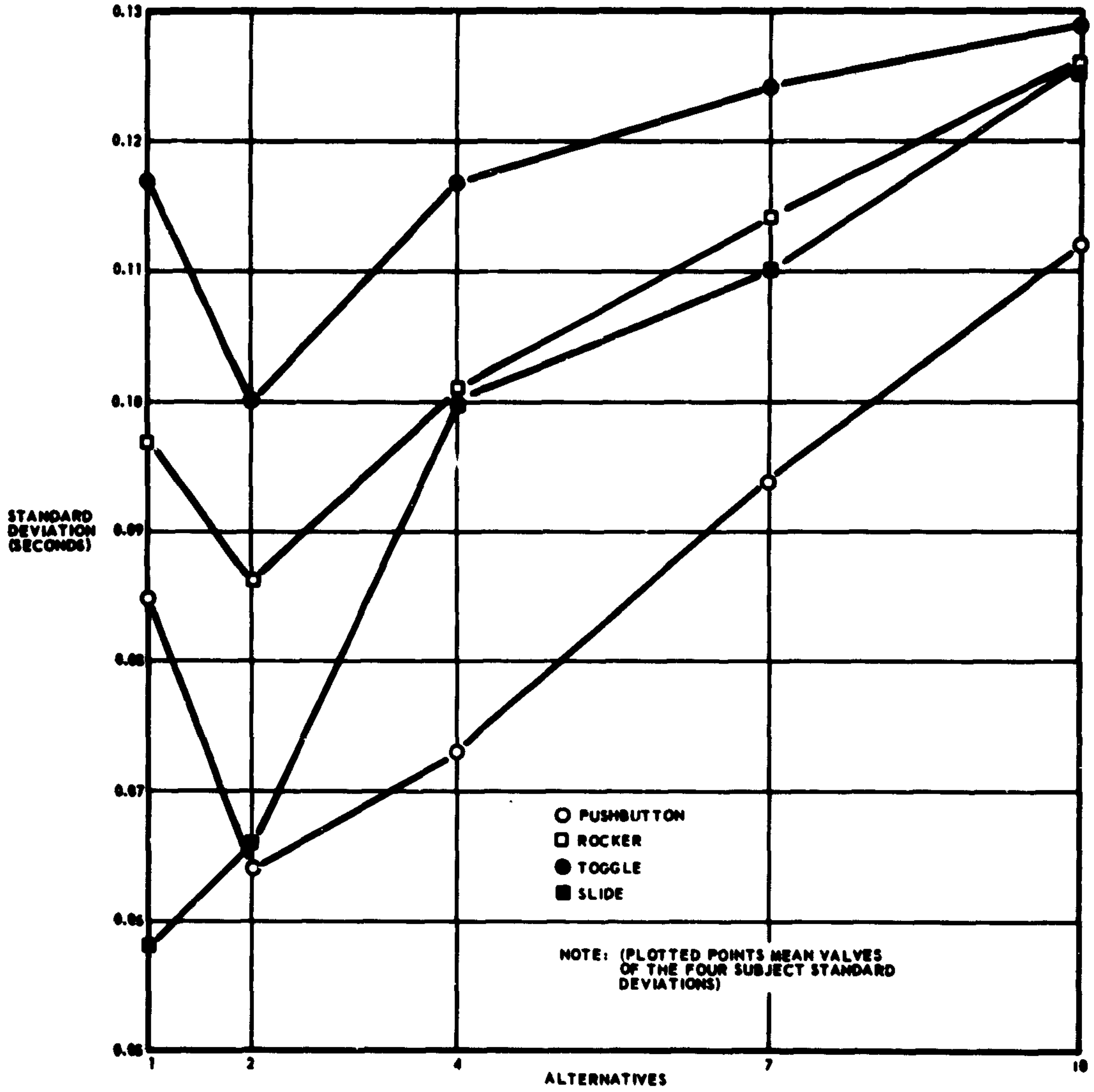


Figure III-4 Performance Variability

TABLE III-4

ERROR DATA

Device	Pushbutton					Toggle					Rocker					Slide					
No. of Alternatives	1	2	4	7	10	1	2	4	7	10	1	2	4	7	10	1	2	4	7	10	Total
Subjects:																					
S_1	0	1	1	1	5	0	0	0	0	0	0	0	0	1	4	0	0	0	1	0	14
S_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
S_3	0	0	0	2	2	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	7
S_4	0	0	1	2	5	0	0	1	1	0	0	0	0	3	0	0	0	1	1	2	17
Total	0	1	2	5	12	0	0	1	1	1	0	0	1	5	5	0	0	1	2	2	
	20					3					11					5					39

to speed of response, from fastest to slowest, is S_4, S_1, S_3, and S_2. The ordering of subjects on performance errors, from most accurate to least, is exactly the reverse of speed, resulting in a reciprocal relation between speed and accuracy across the four subjects. Similarly, pushbuttons, rockers, slides and toggles placed in that order with respect to speed of operation. The ordering of devices with respect to associated errors, from most accurate to least, is the reverse of that for speed, again giving a reciprocal relation between speed and accuracy across devices. Conversely, the correlation between performance speed and errors, with respect to number of response alternatives is negative, with the fastest alternative conditions showing the fewest errors, giving a positive relation between speed and accuracy for the response alternatives parameter.

COMBINED PERFORMANCE MEASURES

The results of this experiment suggest once again the need for a single performance measure combining in some manner both speed and accuracy since the best device from a speed standpoint was apparently not the same as the best from an accuracy standpoint. In past studies of this type, the most popular combining measure is the information transmission rate measure. There are, of course, other measures that have or could be used; time per correct response, percent correct times input bit rate, etc. It may be observed that each combining scheme, of necessity, assigns variable weighting factors to speed and to accuracy. Thus, it is apparent

for any combining model that a given score value can be attained with an infinite number of combinations of speed and accuracy scores. Thus there is a loss of information in the combining process. These considerations form the basis for doubting that any particular combining technique should be universally adopted. The particular combining technique to be used should be selected on the basis of the task requirements of the particular application planned.

For illustrative purposes, the speed and accuracy data of this experiment have been combined by several techniques to show their effect. Given sufficient data, the most exact computation of average information transmitted per response ($T_{in;out}$) is based upon a summation of probabilities of occurrence for each stimulus-response pair. Typically, as in this experiment, error rates are too low and the data sample too small to accurately assess these probabilities. Therefore, approximating techniques are required. Using a computation technique discussed in Blank and Quastler,[1] the average amount of information transmitted per response was taken as the amount of information in the input minus the equivocation. Equivocation was estimated in two parts; $H_{(loc)}$, the information required to locate an error in the output, and $H_{(cor)}$, the information required to correct an error response once located. Inspection of the error data from this experiment revealed no pattern of error occurrence; that is, the occurrence of incorrect responses appears uncorrelated with both the input values and with other error responses. Therefore, random error occurrence

[1] Blank, A. A., and Quastler, H., "Notes on the Estimation of Information Measures", University of Illinois, Report No. R-56, May 1954.

was assumed and

$$H_{(loc)} = P \log_2 \frac{1}{P} + (1-P) \log_2 \frac{1}{1-P} \qquad \text{(III-1)}$$

where

P = percent correct responses.

Error responses when they occurred however, were highly correlated with the input value. In all but one case the correct response was adjacent (right or left) to the actual response. Thus, error correcting is reduced to a two choice alternative or

$$H_{(cor)} = (1-P) \log_2 2 = (1-P). \qquad \text{(III-2)}$$

The average information transmitted per response is then

$$T_{(in;out)} = H_{(in)} - \left(H_{(loc)} + H_{(cor)}\right) \qquad \text{(III-3)}$$

or

$$T_{(in;out)} = \log_2 (K) - P \log_2 \frac{1}{P} - (1-P) \log_2 \frac{1}{1-P} - (1-P) \qquad \text{(III-4)}$$

where K is number of alternatives available. Figure III-5 shows the results of treating the data from this experiment by Equation III-4. Simpler, but less exact, approximations are

$$T_{(in;out)} = P\,H_{(in)} \qquad \text{(III-5)}$$

or

$$T_{(in;out)} = P^2\,H_{(in)}\,. \qquad \text{(III-6)}$$

Results of these latter two equations applied to this experiment are shown in Figures III-6 and III-7, respectively. Figure III-8 shows the maximum channel capacity that would have been obtained in this experiment with the

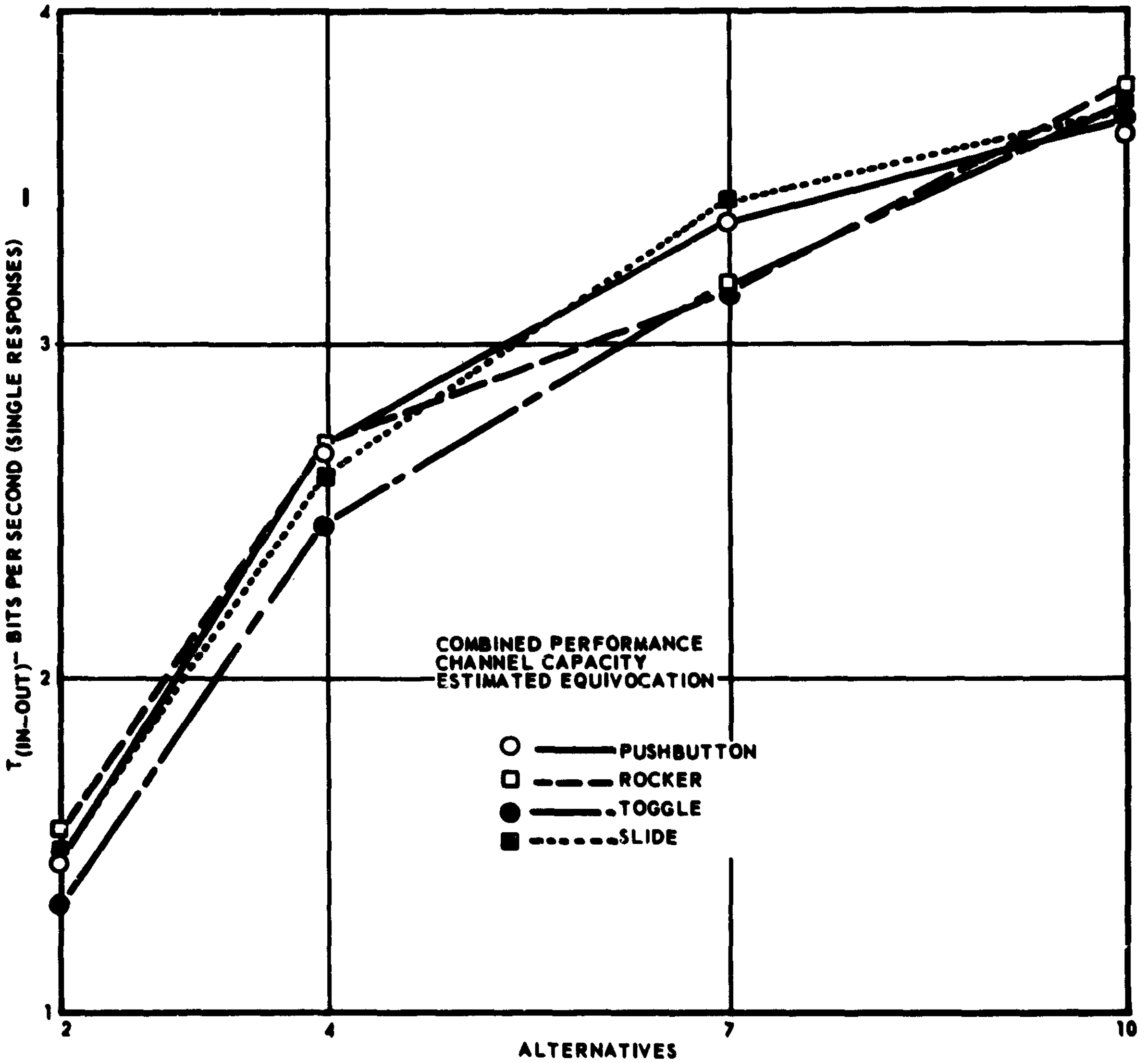


Figure III-5 Combined Performance - Estimated Equivocation

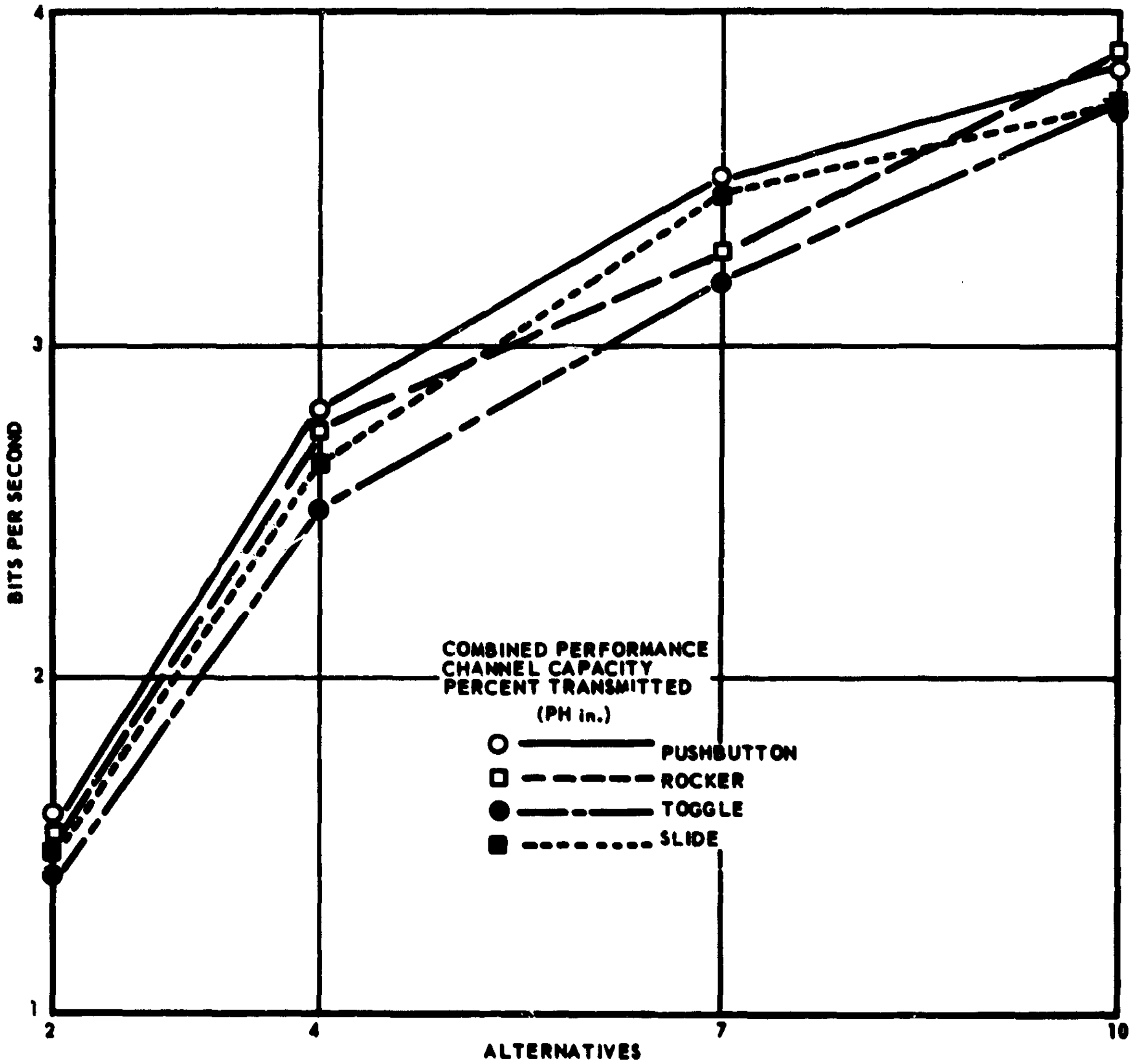


Figure III-6 Combined Performance - Percent Transmitted ($PH_{(in)}$)

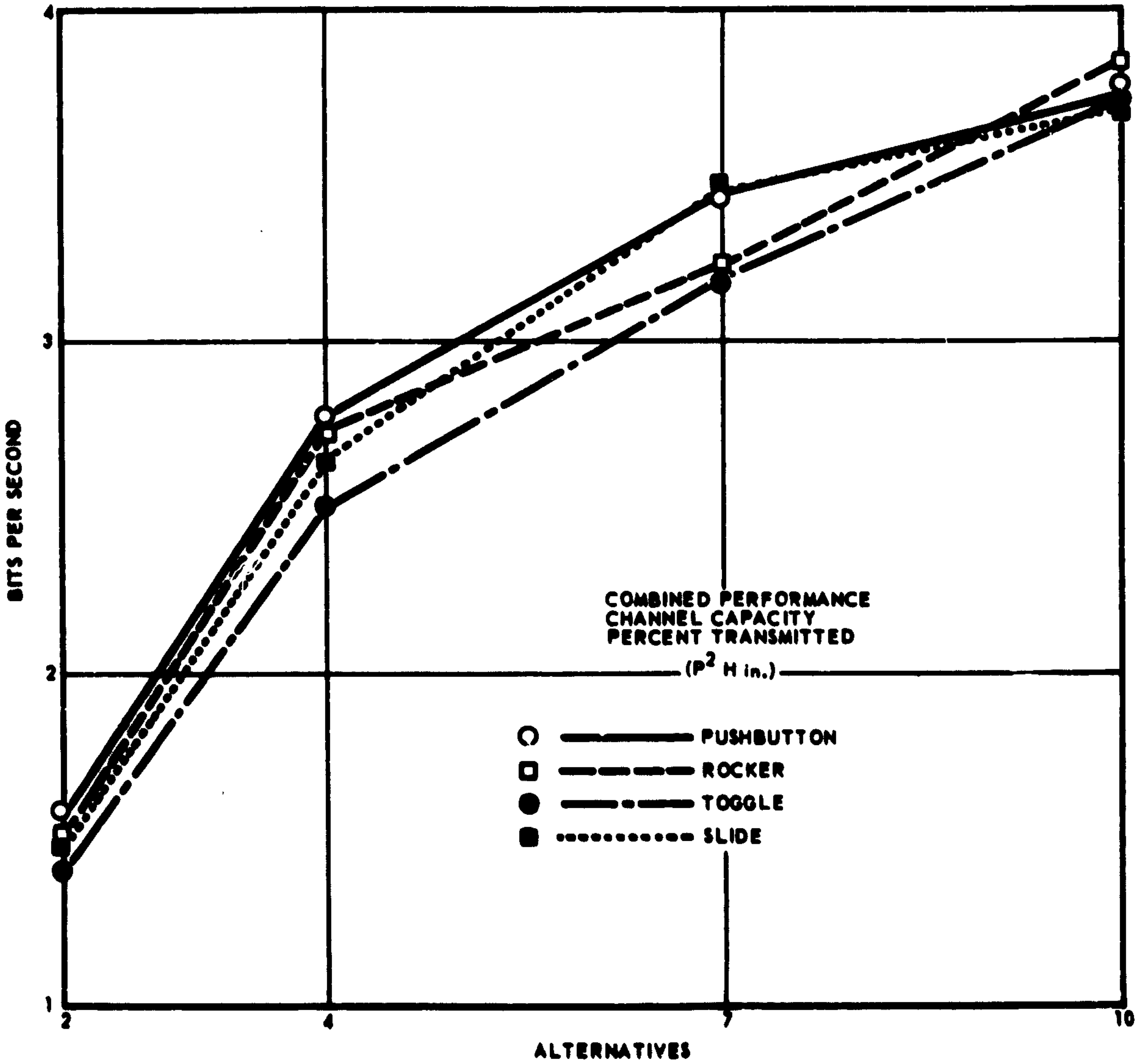


Figure III-7 Combined Performance - Percent Transmitted (P^2H in.)

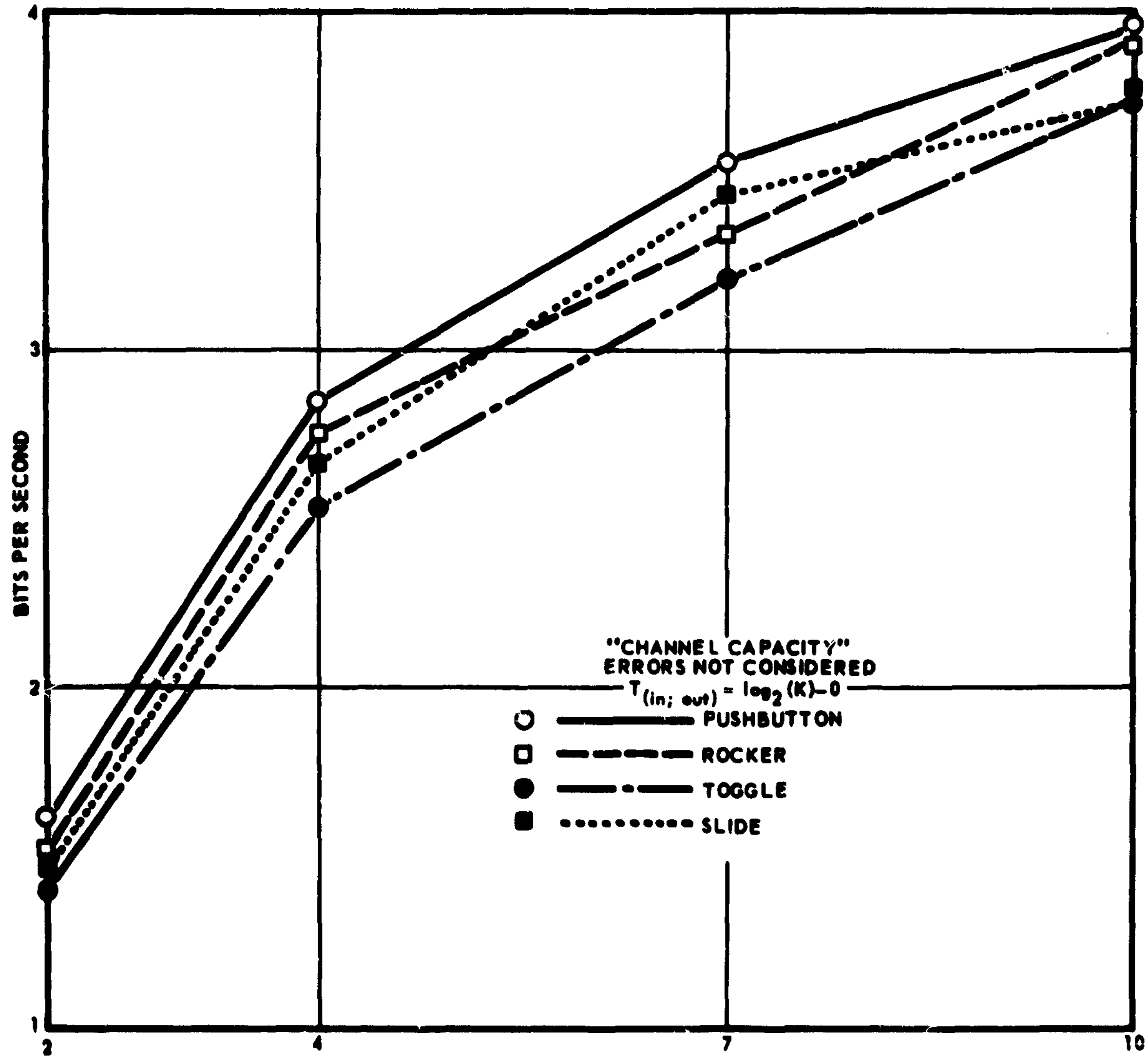


Figure III-8 Maximum Information Transmission
$T_{(in;\ out)} = \log_2(K) - 0$

same speed results but no errors. Comparison of Figures III-5 through III-8 reveals that the presence of errors reduces the significance of device differences. However, the absolute value of the scores change only slightly with the combined scoring techniques.

The manner in which "channel capacity" scores would be affected by errors for the different scoring methods is shown in Figure III-9. This figure shows the estimated number of bits transmitted per response as a function of percent correct responses for four approximation methods and several values of $H_{(in)}$. The maximum equivocation case is appropriate for those instances where errors occur randomly and in which the incorrect response is uncorrelated with the input. In this case,

$$H_{out(in)_{max}} = P \log_2 \frac{1}{P} + (1-P) \log_2 \frac{1}{1-P} + (1-P) \log_2 (K-1).$$

The minimum equivocation case is appropriate for those instances where errors occur randomly but in which the incorrect response is highly correlated with input, as in the experiment reported here. In this case,

$$H_{out(in)_{min}} = P \log_2 \frac{1}{P} + (1-P) \log_2 \frac{1}{1-P} + (1-P).$$

The remaining two cases, percent correct and (percent correct)^2 have no theoretical foundation but were selected for their ease of computation and represent Equations (5) and (6) respectively. For error rates less than about 10%, P^2 is a close approximation to (1-e), where e is percent error. Thus this can be considered a "double penalty" correction model. Inspection

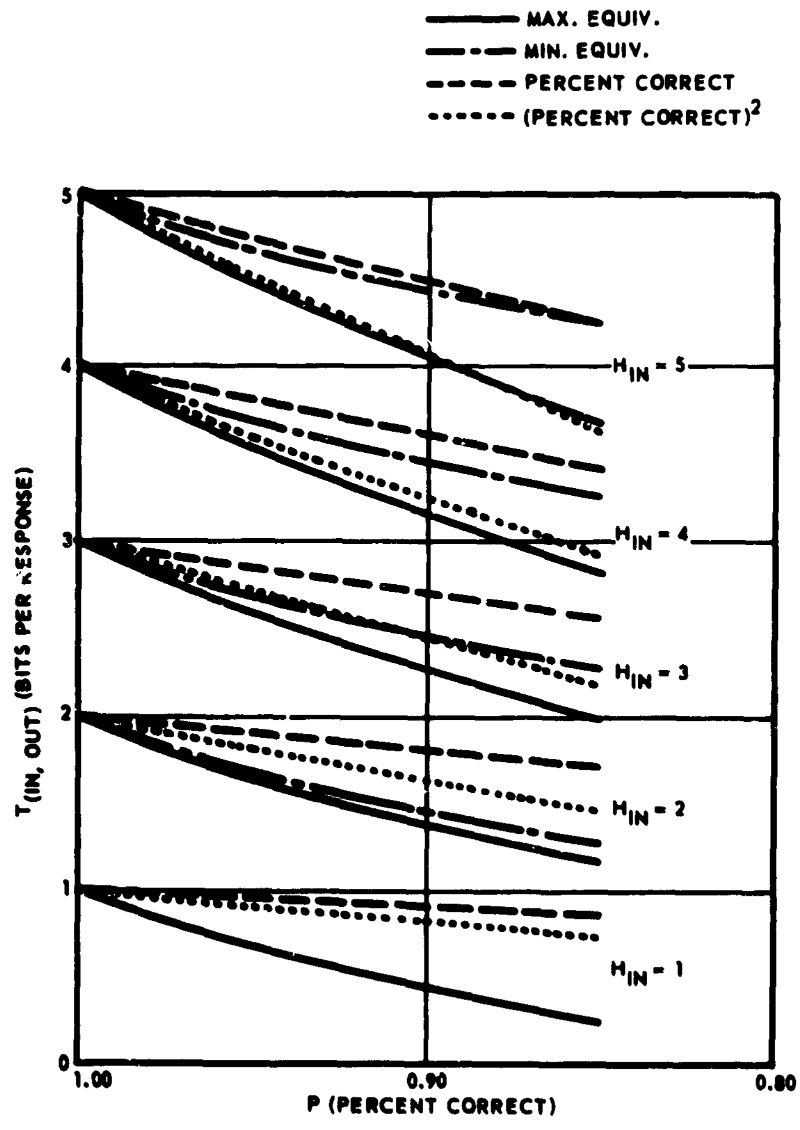


Figure III-9 Effects of Error on Estimates of Information Transmission

of Figure III-9 shows that these simpler computations are reasonable approximations to the equivocation computations for $H_{(in)} > 4$ and $P > 0.9$.

Another way of expressing a combined score is in terms of a corrected time score. In general, this involves multiplying the response time scores by some function of the error rate. Three multipliers have been tried for this experiment; $\frac{1}{P}$, $\frac{1}{P^2}$ and $\frac{H_{(in)}}{T_{(in;out)}}$. Results are shown in Figures III-10, III-11, and III-12, respectively, and reflect increasing levels of error penalties. These figures, when compared with the uncorrected time scores in Figure III-3, again show that the errors in this experiment reduced the significance of device speed differences, but have only a small effect upon the absolute score.

No argument can be made for the superiority of one of the above combined speed and accuracy scoring models over another. Selection of a particular model for a particular evaluation task should be based upon the degree of penalty the designer feels should be placed on the occurrence of an error.

DISCUSSION

While this experiment demonstrates statistically significant performance differences with the devices used, those speed, variability, and accuracy differences are small. In comparing the devices, other factors should be considered. That the devices tested are not identical in ease of operation is borne out by experimenter's observations and by subjects' solicited comments at the end of the experiment. Pushbuttons were

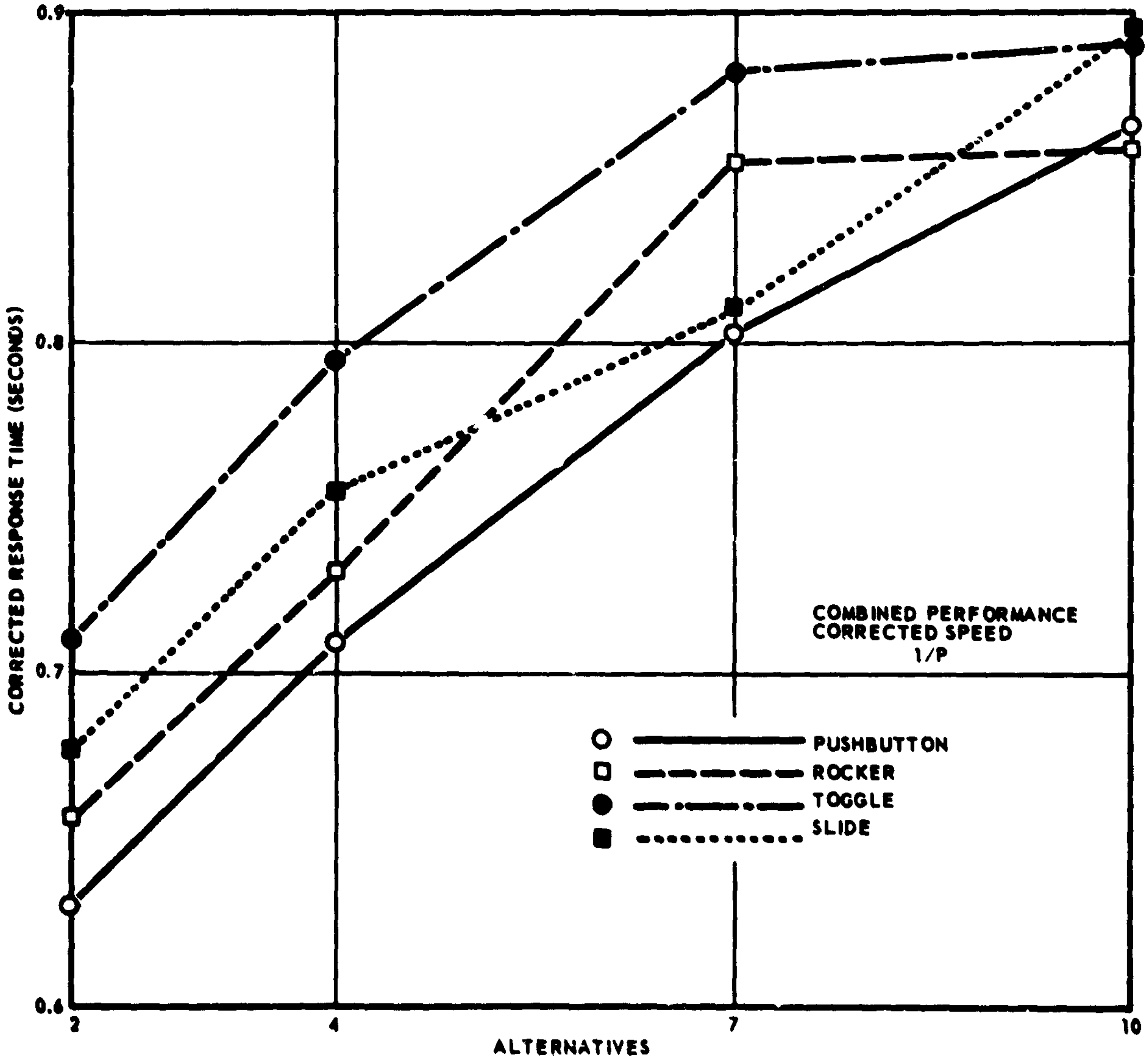


Figure III-10 Corrected Response Time 1/P

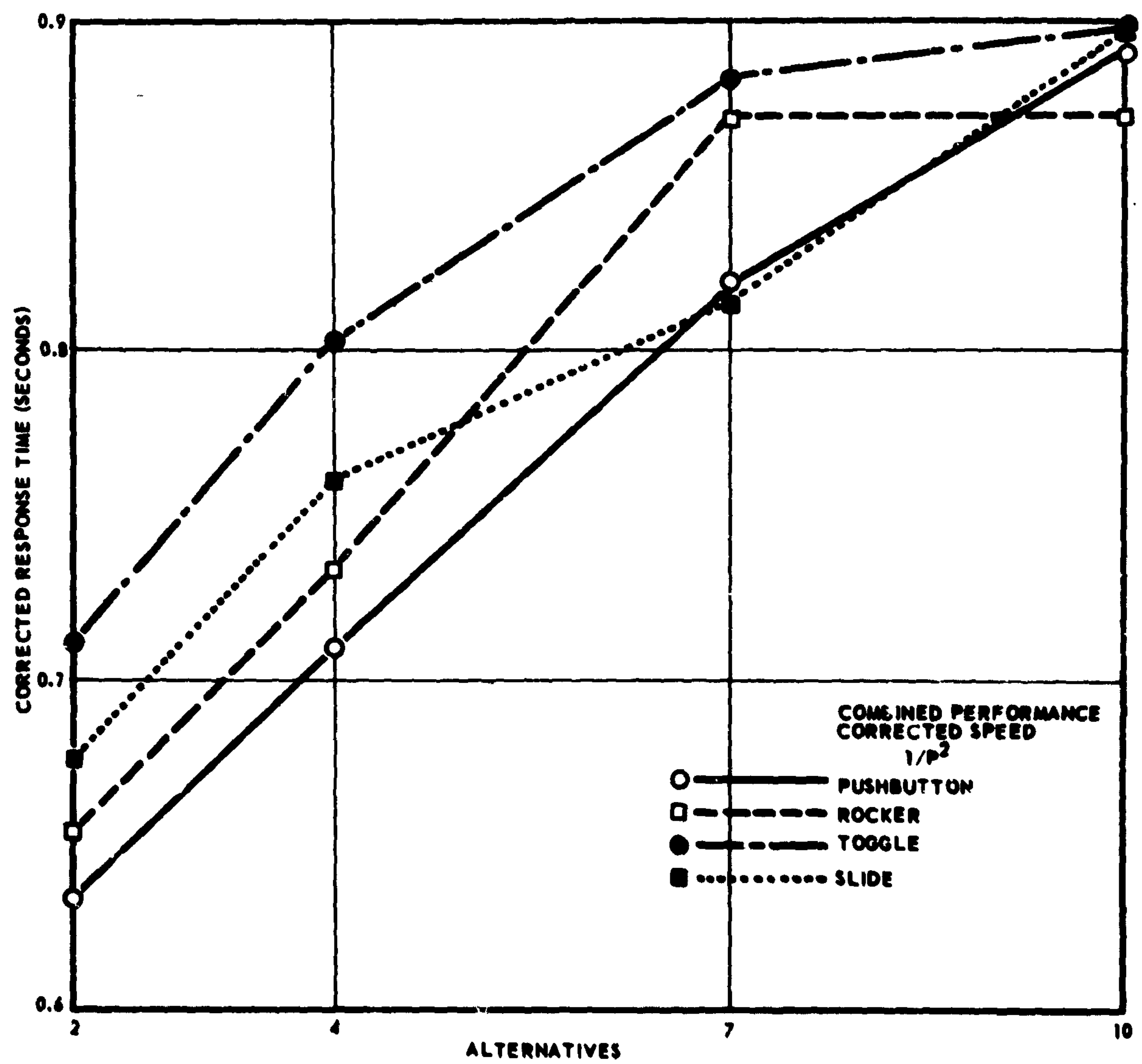


Figure III-11 Corrected Response Time $1/P^2$

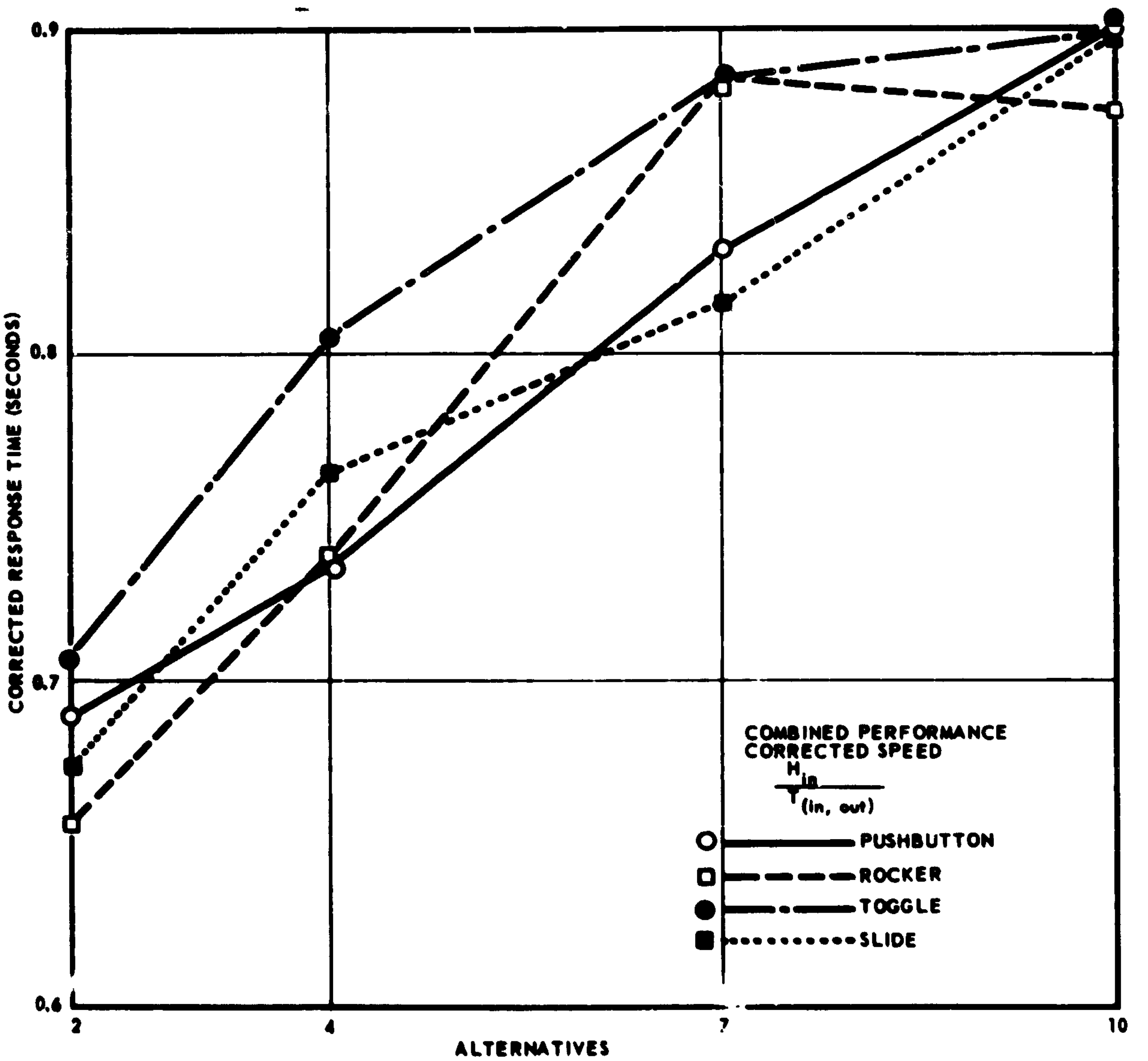


Figure III-12 Corrected Response Time $\frac{H_{in}}{T \text{ (in, out)}}$

reported as the easiest to operate since they offered the largest target area and the required direction of motion permitted the simplest motor action. Thus, there existed a tendency to operate the pushbutton with a ballistic-like movement resulting in increased speed, but reduced accuracy. At first glance the rocker switch appears to have a rather large operating target. This is not the case, however. Only pushing the lower edge of the bottom half of the exposed area is effective in operating the rocker. If pressed at this point it can and could be operated with a straight pushing action. Operated above this point, however, a distinct rocking motion, i.e., down and in, is required. The slide and toggle switches required the most difficult actuation movements; for each, the finger was placed above the appropriate switch and then brought down on the switch. Also each of these devices presented a small operating target and it was necessary for the subject to position his finger rather precisely in order to operate the switch at all.

The simple reaction condition, 1 alternative, considered in this experiment was not a part of the primary investigation but was included to provide a base-line check for the data and a point of comparison with previous studies. Average simple reaction times measured in this experiment ranged from 0.49 to 0.63 seconds. These values compare favorably with two studies[2,3]

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[2]Bradley, J. V. and Wallis, R.A., "Spacing on On-Off Controls II; Toggle Switches," WADC TR 58-475, March 1959.

[3]Bradley, J. V., "Effect of Gloves on Control Operation Time," WADC TR 56-532, November 1956.

using toggle switches in which movement times of about 0.5 seconds were reported and with two pushbutton studies[1,2] in which movement times of 0.3 and 0.6 seconds were measured.

The time scores of this experiment represent total reaction times inasmuch as the apparatus dis not permit separate measurement of device operation and movement times.

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[1] Bradley, J. V., "Effect of Gloves on Control Operation Time," WADC TR 56-532, November 1956.

[2] Bradley, J. V. and Wallis, R. A., "Spacing of On-Off Controls I; Pushbuttons," WADC, TR 48-2, April 1958.